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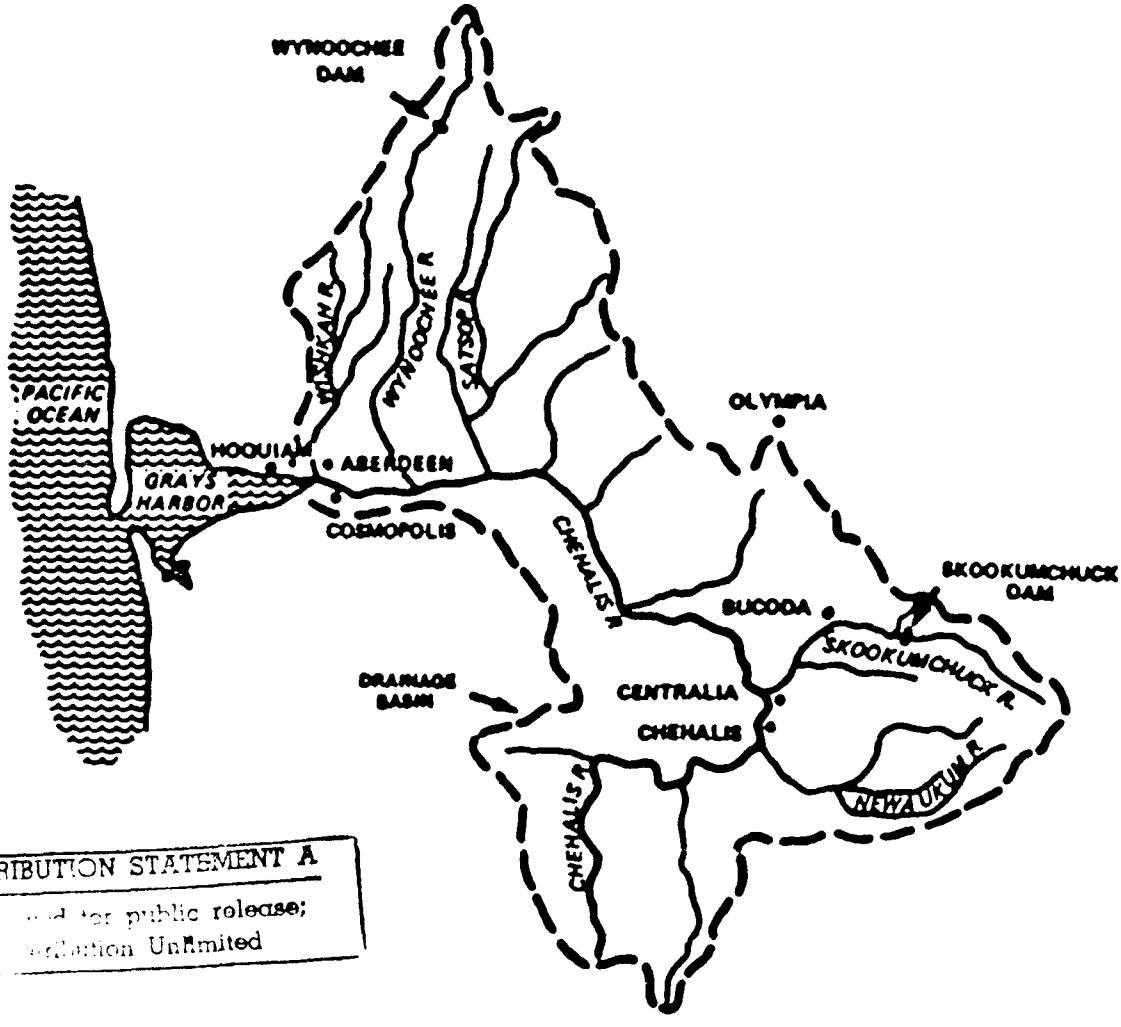
Flood Summary Chehalis River Basin January 1990 Event

(and Nov.'90 Event Addendum)

US Army Corps
of Engineers
Seattle District

Report Date: 31 May 1991



SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	unlimited
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION: Seattle District, U.S. Army Corps of Engineers / 6b. OFFICE SYMBOL (If applicable): CENPS-EN	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code): P.O. Box 3755, Seattle, WA 98124-2255	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING / SPONSORING ORGANIZATION / 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

Flood Summary Chehalis River Basin January 1990 Event(and Nov.'90 Event Addendum)

12. PERSONAL AUTHOR(S)

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
	FROM Jan'90 TO Nov'90	31 May 1991	79

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Chehalis River Basin, Washington Floods, 1990

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The main report documents the 100-year flood event on the Chehalis River above Grand Mound. The report is organized into five primary categories: meterology, hydrology, damage estimates, river forcasts and flood fighting. An addendum is provided to briefly discuss some observations of the flood that occurred in November 1990.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Lester E. Soule	22b. TELEPHONE (Include Area Code): (206)764-3699 / 22c. OFFICE SYMBOL: CENPS-EN-PL-CP

DD Form 1473, JUN 86 *Previous editions are obsolete*

SECURITY CLASSIFICATION OF THIS PAGE

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January 1990 Event
(and Nov. '90 Event Addendum)

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1. Purpose. The purpose of this report is to document Chehalis River flood data for the flood of 8-12 January 1990. Although high water and flooding occurred in other basins, the scope of this report has been limited to the Chehalis River basin. An addendum is provided to briefly discuss some observations of the flood that occurred in November 1990.

2. Background. The disaster reported herein is the result of a rain flood event in western Washington that occurred during 8-12 January 1990. Flood waters on the Chehalis River exceeded the previous flood-of-record. Interstate 5 was closed in the Chehalis-Centralia area because of this flood. Lewis County was declared a disaster area by Governor Gardner and President Bush with initial damage estimates of $12 to $15 million. Federal emergency assistance was made available for Lewis, Thurston, and Grays Harbor counties in the Chehalis River basin. Preliminary analysis by the U.S. Army Corps of Engineers (Corps) indicates this was a 100-year flood event for much of the mainstem Chehalis River above Grand Mound and a 45-year event for the Skookumchuck River near the mouth. Flood reporting primarily covers the basin above Grand Mound since flooding below this point was not as severe as had been forecast.

3. Introduction. This flood report is organized under five primary categories: meteorology, hydrology, flood damage estimates, river forecasts, and flood fighting. The meteorology portion covers the atmospheric characteristics of the storm as it passed over the basin, while hydrology covers the characteristics of the runoff across the basin and into the rivers. The section on damage estimates reports observations of flood-caused damages by region and category. Economic data are based upon field observations taken by personnel from the Hydraulics and Economic & Social Evaluation Sections of Engineering Division. Meteorology and hydrology data were obtained from the files of the Reservoir Control Center in Hydrology and Hydraulics Branch. A region and location map are included which show key features in the area (see plates 1 and 2). An outline of the Skookumchuck and Chehalis River basins is shown on plate 3. For reporting purposes, the basin is organized into the following subbasins:

- upper Chehalis (above Skookumchuck River and including Newaukum River),
- Skookumchuck River,
- middle Chehalis (Skookumchuck to Porter including Oakville and Grand Mound),
- lower Chehalis (Porter to Aberdeen), and
- Aberdeen at the mouth of the Chehalis River.

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METEOROLOGY

4. Weather. Precipitation from a stalled, southwesterly moving weather system over the Chehalis-Nisqually-Puyallup river region produced copious amounts of rainfall and runoff at some stations in the Chehalis basin, primarily in the upper half of the basin, that approached or exceeded previous records. One factor in the high runoff observed for this event was the persistent wet weather that occurred prior to 8 January. Figure 1 illustrates the antecedent precipitation that began 5 days before the flood producing rainfall. The two stations that are plotted typify the relationship between cumulative rainfall and runoff. The Frances precipitation station is near the headwaters of the Chehalis River. The Skookumchuck River gage is used for runoff comparison because the Centralia station and Doty station (near the Chehalis River headwaters) had missing data for the earlier days. The Skookumchuck River has a mean basin elevation of 1,700 feet and the Chehalis River above Doty, in the vicinity of the Frances precipitation station, has a mean basin elevation of 1,000 feet. The ground conditions were primed to a wet condition during the early rainfall which explains why the runoff and precipitation plots on figure 1 are proportionally matched.

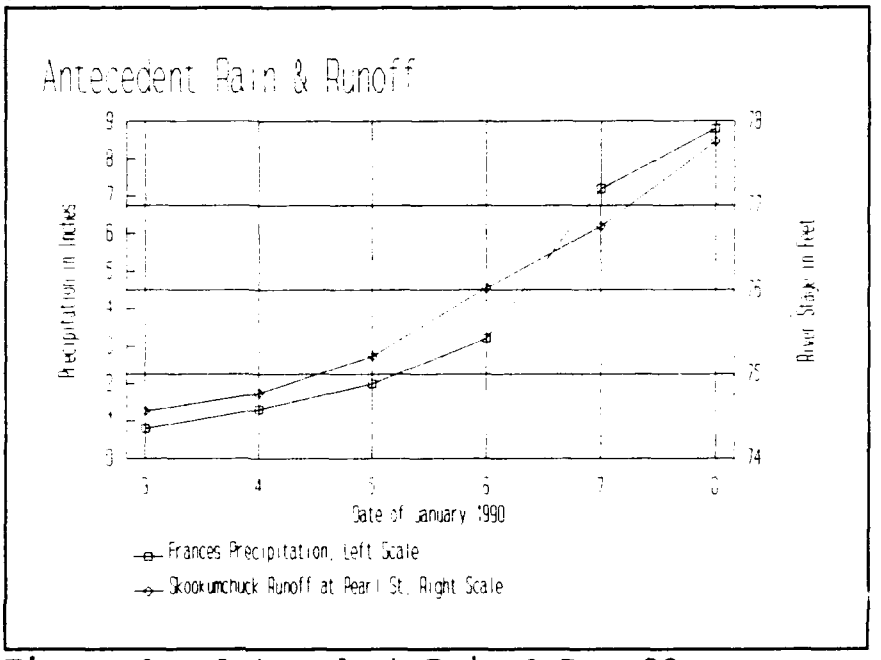


Figure 1. Antecedent Rain & Runoff

5. Coastal Weather Watch. By the afternoon of Monday, 8 January, atmospheric conditions intensified and weather watchers anticipated that this was going to be a significant event. The National Weather Service (NWS) began issuing their written notices with Bulletin No. 1 at 3 p.m.:

> "Another in the current series of storms is on the South Washington coast at this time and will be spreading inland this evening. This is another very wet and fairly warm storm with freezing levels above 5,000 feet."

The NWS also went on to say that the effects of wind, low atmospheric pressure, heavy swells, and river runoff may increase tide levels. As the weather arrived, continued bulletins reported detailed observations on air temperatures, freezing levels, precipitation, and river runoff.

6. Temperature. The warm temperature of the air mass allowed a greater than usual amount of moisture to be carried inland. By the evening of 8 January, coastal weather stations along the

Washington coast and northern Oregon coast were reporting maximum temperatures reached during the day of 50 degrees Fahrenheit (°F). Normal minimum and maximum temperatures for this time of year at Centralia average between 34°F and 45°F, respectively. The Portland area was being affected by the same weather that was headed for the Chehalis basin and served as an alert station for the magnitude of the storm. The storm began to reveal itself as having record-breaking potential as details were reported. At 4:30 a.m. on 9 January, the NWS Office in Portland reported a high temperature of 57°F at the airport for 8 January which equaled the record for the day. Warming continued on Tuesday, the 9th. At 4:30 p.m., the Portland NWS office reported that a new record maximum temperature of 61°F was observed at the Portland airport, exceeding the old record of 56°F, set in 1953. The report also said that a new record maximum temperature of 61°F was observed at Salem. The freezing level at the time of the report was 8,500 feet at Salem.

7. Freezing Level and Snowpack. The only location along the Washington coast where the freezing level is reported is at Forks, Washington, located near the northwest tip of the Olympic Peninsula. Salem, Oregon is the only other reporting station near the coast that is south of Chehalis. The Chehalis River basin is just about midway between these two locations. The freezing level at these two locations is shown for the storm duration on figure 2. The freezing level is plotted twice a day. The number to the left of the decimal on figure 2 is the day. The decimal portion of the day indicates the time within the day (.2 is at about 5 a.m. and .7 is at about 5 p.m.). Most of the precipitation occurred during 9 January. With warm rain falling on the snowpack (where present), snowmelt contributed additional water into the higher reaches of some basins in western Washington during the disaster. At the onset, the snowline was about 3,000 feet mean sea level (MSL). On 8 January, snowmelt occurred between 3,000 and 5,500 feet MSL. There was additional snowmelt between 3,000 and 6,000 feet MSL on both 9 and 11 January. However, the portion of the Chehalis basin above these elevations is small, and the snowpack was small enough that snowmelt was not a major contributor to the flood runoff.

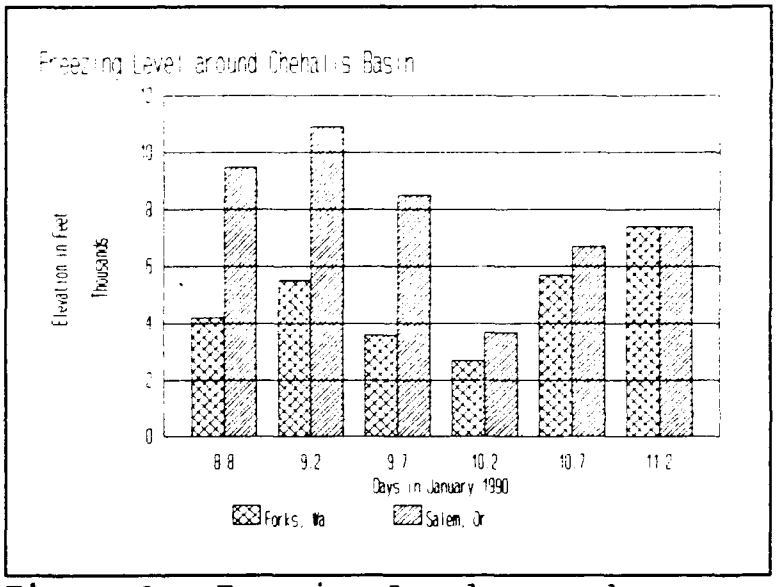


Figure 2. Freezing Level around Chehalis Basin

8. Precipitation, 8-9 January. Precipitation at major cities around the region was reported on the teletype data terminal by the Seattle and Portland offices of the NWS at 4 p.m. and 5 p.m., respectively, on Monday, 8 January. Rainfall intensified late that night. At 6:50 a.m. on Tuesday, 9 January, the following Special Weather Statement was issued:

> "The National Weather Service has issued an urban flood statement for Puget Sound this morning. Heavy rain has occurred over a large area of Puget Sound with amounts approaching

2 inches in the Olympia area and Tacoma area. Olympia is still reporting heavy rain as of 6 AM this morning. Motorists should be on the lookout for standing water in all low places like underpasses and along small creeks and waterways. Motorists are advised not to try to drive through these flooded areas. The rains will be decreasing by late morning or early afternoon and turn to showers."

Shortly afterwards, at 8 a.m. on Tuesday, another bulletin was issued that extended the rain period and was the first mention of potential serious flooding:

"Heavy rain will continue through all of today and into the late night. This along with high freezing levels will cause many rivers in western Washington to go above flood stage or get close to it..."

By this time, personnel in the Seattle District Reservoir Control Center had been tabulating precipitation at three locations around the Chehalis River that were consistently reporting: Aberdeen, on the north side of the basin; Frances, on the south side; and Cinebar, on the east side of the basin. Mass plots of the precipitation accumulations at these stations is shown in figure 3. Precipitation was also observed at other stations such as Centralia, a good long-record station near the flood-prone area; however, the other stations were not reliably reporting every hour. The stations in figure 3 provided the most complete record throughout the storm (except for a small gap near the end of the Cinebar plot). Frances received precipitation first and recorded the greatest incremental amount. Cinebar lagged only a few hours behind Frances and recorded nearly the same amount. The Aberdeen station, which represents the north slopes of the basin, began receiving precipitation about 3 hours after the coast (Frances) and diminished about 5 hours before the interior station (Cinebar). The intensity of the rainfall was nearly uniform throughout much of the middle and upper basin as indicated by the nearly parallel segments of the mass plots for Frances and Cinebar on figure 3. The lesser total accumulation at Aberdeen helps explain the lighter runoff observed from this lower-basin region when compared to the rest of the basin. Observing that precipitation on the Washington interior diminished about 5 hours after the coast, and knowing the distance between the stations of about 50 miles, it can

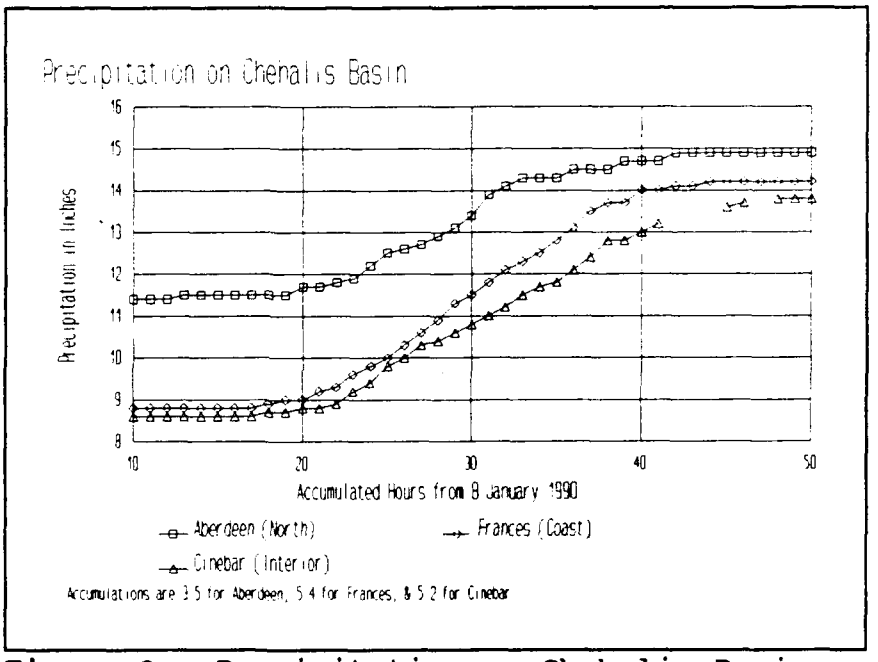


Figure 3. Precipitation on Chehalis Basin

be inferred that the moisture in the air mass was traveling across the basin at about 10 miles per hour.

At 11 a.m. on 9 January, the NWS issued the following Record Precipitation Report:

> "Between 1 and 10 AM...Seattle-Tacoma airport received 2.38 inches of rainfall. This far exceeds the record 24 hour rainfall for January 9th which was 0.77 inches set in 1968. Some other statistics associated with this morning's rain are; rainfall between 4 and 7 AM...1.03 inches, rainfall between 7 and 10 AM...1.01 inches... The all-time record 24 hour rainfall was 3.74 inches set on October 5th and 6th...1981. The peak 3 hour rainfall total during that system was 0.95 inches... The six hour rainfall amount recorded during this morning's storm qualifies as a once every 100 years occurrence."

9. Precipitation, 10 January. By 5 a.m. on 10 January, the storm activity ended and the NWS issued the following report:

> "Drier air moved into the state overnight bringing an end to the heavy rainfall of recent days. Only light amounts were reported after midnight... Skies ranged from mostly clear in the northwest section to cloudy southeast... 4 AM temperatures were running up to 15 degrees cooler than yesterday...coldest reported was 35 near Forks on the coast. Precipitation was torrential in portions of the cascades yesterday and last evening. The Crystal Mountain area near Mt. Rainier had 5.6 inches..the Snoqualmie Pass area 5.2 inches and Stevens Pass 4.2 inches over the last 24 hours... Rainfall at some of the southwestern cities during the past 24 and 48 hours..."

	Precipitation During Two Durations:	
City	24 Hours	48 Hours
Seattle	2.38 inches	3.00 inches
Tacoma	3.22 inches	4.55 inches
Olympia	2.99 inches	4.64 inches
Astoria, Oregon	3.43 inches	5.39 inches
Portland, Oregon	.82 inch	1.62 inches

The total two-day storm rainfall for this event over the Chehalis River basin above Grand Mound was estimated to be about 5.3 inches (using an average of precipitation stations around the basin, weighted by an estimate of the relative area each station represented over the basin). This estimate was made to compare with the actual runoff of 5.1 inches (see paragraph 13). Storm amounts for the Centralia precipitation station are tabulated in table 1 for comparison with other large storms observed during nearly 100 years of record (1893-1990). The January 1990 quantities did not set new records at this station, but were among the greatest observed. The

Table 1. Precipitation Totals (inches) Ranked for 5 Storms at Centralia

Month &Year	One Day	Month &Year	Two Day	Month &Year	Three Day
Dec 1933	3.95	Nov'86	6.09	Nov'86	6.49
Jan 1990	3.36	Dec'33	5.10	Oct'42	5.80
Nov 1986	3.22	Oct'42	4.75	Dec'33	5.49
Oct 1942	3.22	Jan'90	4.13	Dec'37	5.41
Feb 1951	3.15	Nov'32	4.02	Jan'90	5.35

1-day amount for January 1990 was even greater when considering a different time interval than the 6 p.m.-to-6 p.m. interval established for record keeping. From 9 p.m. on the 9th through 9pm on the 10th, 4.13 inches of precipitation were measured at Centralia.

HYDROLOGY

10. Hydrographic Data. Hydrographic data reported here include time varying river discharges and stages. Data along the Chehalis River are reported from seven United States Geological Survey (USGS) streamgage stations and two unrated NWS stations. Data is also kept by the city of Centralia primarily for the NWS stations. The NWS stations record only stages while the USGS stations record stages and discharges. Peak discharges and other hydrologic data and characteristics for pertinent Chehalis basin stations are listed in table 2. NWS forecast points and damage levels in the Chehalis river basin are provided in table 6, paragraph 18. Flooding was evident on Salzer and China creeks; however, only limited flood data were available on these creeks (paragraph 11). The Skookumchuck discharges shown for the Centralia, Bucoda, and Pearl Street stations may not be accurate due to out-of-channel flows as discussed in paragraph 12. The recurrence intervals of the peak data for the January 1990 flood are given in the text based on the most recent discharge-frequency curve computation, as shown by date within parenthesis.

Table 2. Streamgage Data - January 1990

River and Gage	Type	River Mile	Drain Area	Peak Stage	Peak Discharge	Peak Hour	Peak Dy
Chehalis River near Doty	USGS	101.8	113	19.87	27,000	1400	09
Newaukum R. near Chehalis	USGS	4.1	155	12.75	10,600	1830	09
Skookumchuck R. near Vail	USGS	28.8	40	10.01	5,410	1500	09
Skookumchuck R. near Bloody Run	USGS	20.7	66	12.53	8,000	2100	09
Skookumchuck R. near Bucoda	USGS	6.4	112	17.33	8,540	0400	10
Skookumchuck R. at Pearl St.	NWS	2.3	172	87.10	10,800e	0700	10
Chehalis River at Centralia	NWS	67.4	653	73.38	NA ↓	0800	10
Chehalis R. nr. Grand Mound	USGS	59.9	895	19.34	68,700	1200	10
Chehalis River at Porter	USGS	33.3	1294	24.37	58,200	0300	11
Satsop River near Satsop	USGS	2.3	299	31.44	18,500	1900	09

NA = Not Available (stages only) e=estimate

11. Upper Chehalis. The uppermost gage in the Chehalis basin is on the Chehalis River near Doty. The discharge at Doty rose quickly with the rainfall and receded as quickly after the rainfall ceased. The Doty hydrograph is shown on figure 4. The bankfull discharge is unknown, but the average annual maximum discharge at the Doty gage is about 9,500 cfs. Flood runoff at Doty was above this average for 22 hours. The hydrograph peaked immediately after the rain stopped at the Frances gage. The peak discharge of 27,000 cfs has a recurrence interval of about 100 years (1974). A gage on the Newaukum River recorded a peak discharge of 10,600 cfs, with a recurrence interval of about 50 years (1978). Newaukum peaked about 4½ hours after precipitation ceased at the Frances station. A limited record of hourly data was available for the Newaukum gage, and is shown on figure 4. The Chehalis River also picked up inflow from Salzer and China Creeks before it reached the Skookumchuck River. Verbal reports from City officials indicate that China Creek probably peaked at 1700 hours on 9 January and Salzer Creek peaked late at night on 9 January. High water marks have been established at a number of locations on Salzer Creek and China Creek.

Inundation limits have been mapped for China Creek by the city of Centralia and are available in Seattle District Corps of Engineers files. Rated discharges for the high water marks and associated times of occurrence are not available.

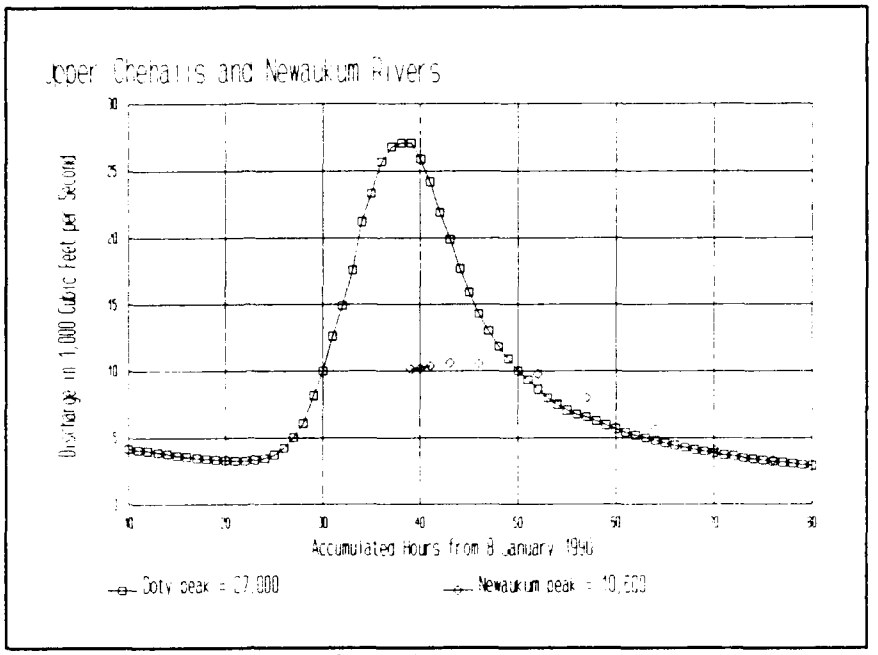


Figure 4. Chehalis River Hydrographs - Upper Basin

12. Skookumchuck River. The Skookumchuck River has discharges recorded at three USGS locations: near Vail, near Bucoda, and below Bloody Run Creek, near Centralia. The last location is about 1 mile downstream of Skookumchuck Dam. Skookumchuck stages are observed at the NWS gage at Pearl Street. Discharges at the Vail gage rose almost parallel to those at the Doty gage and peaked at 5,410 cfs, 1 hour later than Doty. The flow at Vail peaked immediately after the rainfall intensity at Cinebar began to diminish. The recurrence interval of the Vail peak is about 10 years (1981). The Skookumchuck below Bloody Run gage had missing data for about 10 hours around the peak. The peak itself was estimated by the USGS with a preliminary figure of 8,000 cfs and occurred about 6 hours after the Vail peak. Later calculations based on a routing analysis by the Corps of Engineers showed the peak to be approximately 6,750 cfs, or about a 50-year event (1981 "Existing Condition"). The natural peak flow (without Skookumchuck Dam) was calculated to be approximately 7,400 cfs with the peak occurring about 8 hours earlier than the actual peak. The Bucoda gage had continuous observations during the flood. Figure 5 shows plotted discharges observed during the flood for these stations. The discharges may not be accurate due to out-of-channel flows that may have bypassed the gages and also due to the lack of physical measurements relating stage and discharge for such high flows. Calculations by the Corps show the peak discharge at the mouth of the Skookumchuck River to be approximately 11,700 cfs, which is approximately a 45-year event (1981 "Existing Condition"). When comparing peak discharges with their drainage areas for the Skookumchuck River in table 2, the magnitude of the runoff on the Skookumchuck River was found to be less than for the Chehalis River above the confluence with the Skookumchuck.

13. Middle Chehalis. The lowest streamgage on the Chehalis River that provided continuous data during this flood was at Grand Mound. The discharge at this station (figure 6) rose at about the same rate as the upstream gages. The hydrograph remained above zero damage stage for 115 hours and above major damage for approximately 40 hours. The peak discharge of 68,700 cfs was a new record for the gage and has approximately a 100-year recurrence interval (1978). Runoff

for this location averaged about 5½ inches across the basin. This runoff is nearly the same as the basin average precipitation, indicating there was very little precipitation loss during the storm. Either the antecedent rainfall satisfied the losses or there was gaging error in observed quantities. The intensity of the runoff diminished downstream from Grand Mound. A gage is also located at Porter, 26½ miles downstream. A continuous hydrograph is not available at Porter, but the peak discharge was estimated at 58,200 cfs (figure 6). This is somewhat lower in actual and unit discharge than Grand Mound and the recurrence interval is about 50 years (1977). Between Grand Mound and Porter, there was a streamgage operating near Oakville until 1977. The maximum observed peak near Oakville occurred during January of 1972. Figure 7 is a comparison of peak discharges at locations above and below Oakville for years 1972 and 1990. Although there is no observation at Oakville for 1990, one can infer from the chart that the peak for Oakville (Oakv) was probably between the magnitude of the peaks observed at Grand Mound (G.Mnd) and Porter (Port). The 1990 flood probably would have set a new record at the Oakville gage. The chart also shows the trend of an increasing discharge from Grand Mound to Porter in 1972 and a trend of a decreasing discharge from Grand Mound to Porter in 1990. The

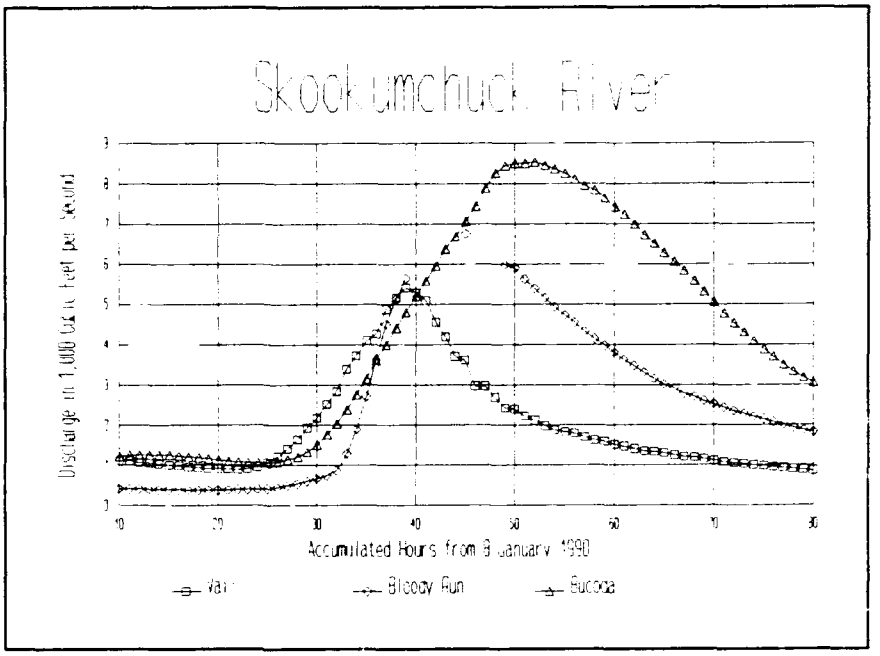


Figure 5. Skookumchuck River Hydrographs

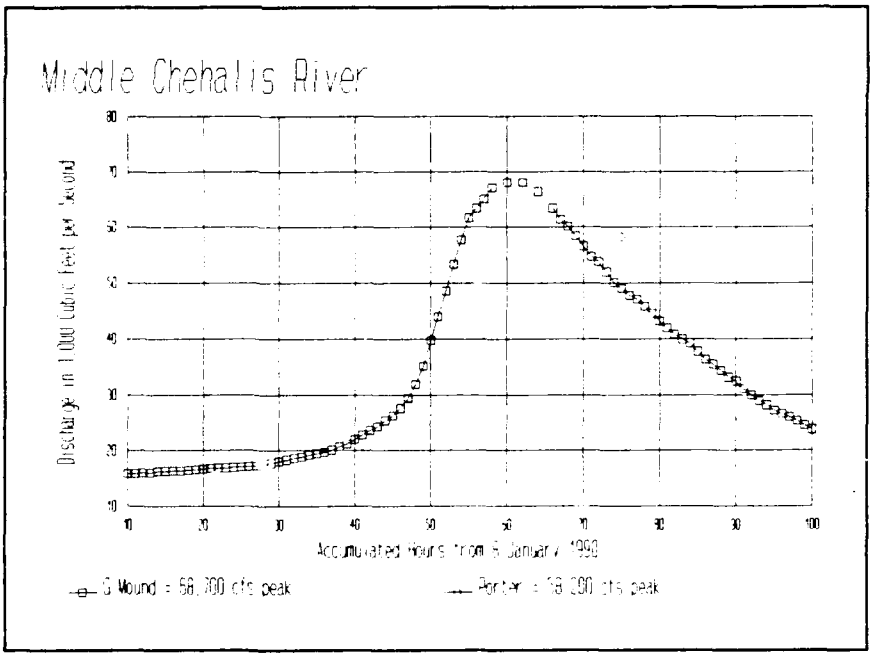


Figure 6. Chehalis River Hydrographs - Middle Basin

increasing trend of discharge is the more typical pattern for this reach of river. While researching peak flow data at the Oakville gage, six out of seven large flood events had discharges greater at Oakville than at Grand Mound. This experience is remembered by river watchers, so when a forecast is provided at Grand Mound, one expects to see greater discharges downstream at Oakville and Porter. The decrease in peak flow observed in January 1990 downstream of Grand Mound was unexpected. No assessment has been made as to the cause of the decrease in flooding as the river proceeded downstream.

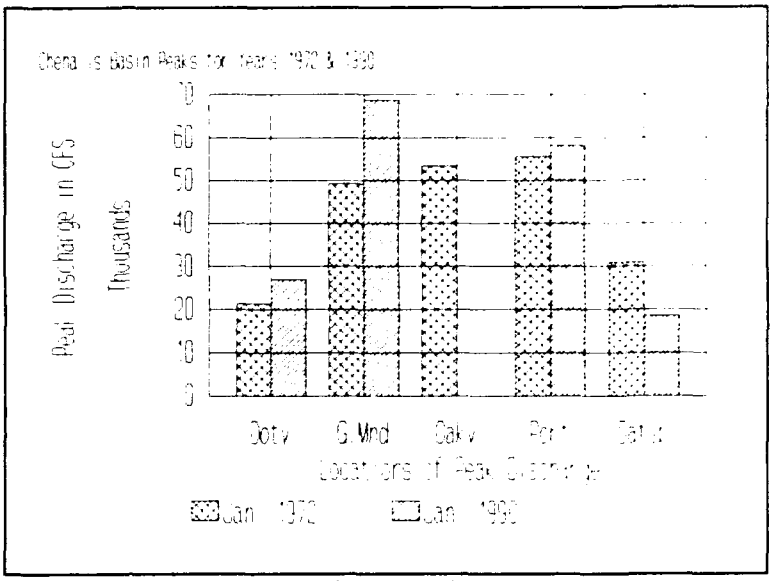


Figure 7. Chehalis Basin Peaks for Years 1972 & 1990

14. Lower Chehalis. The reduced runoff in the northern segment of the Chehalis river basin including the Aberdeen-Hoquiam area is evident based upon observation of the Satsop River gage. This is primarily a result of reduced rainfall in this portion of the basin as explained earlier. The Satsop River drains almost 300 square miles and its runoff should be typical of the drainage along the north side of the Chehalis River. The Satsop River is plotted on figure 8 for comparison with the mainstem gage at Grand Mound and the headwater gage at Doty. The Satsop peak discharge of 18,500 cfs has less than a 2-year recurrence interval (1977). The timing of the Satsop runoff shows that it arrived at the confluence of the Chehalis River more than 15 hours prior to the peak of the mainstem Chehalis at Grand Mound. The secondary rise on the Satsop hydrograph may be the backwater effect of the Chehalis high water arriving at the Satsop vicinity.

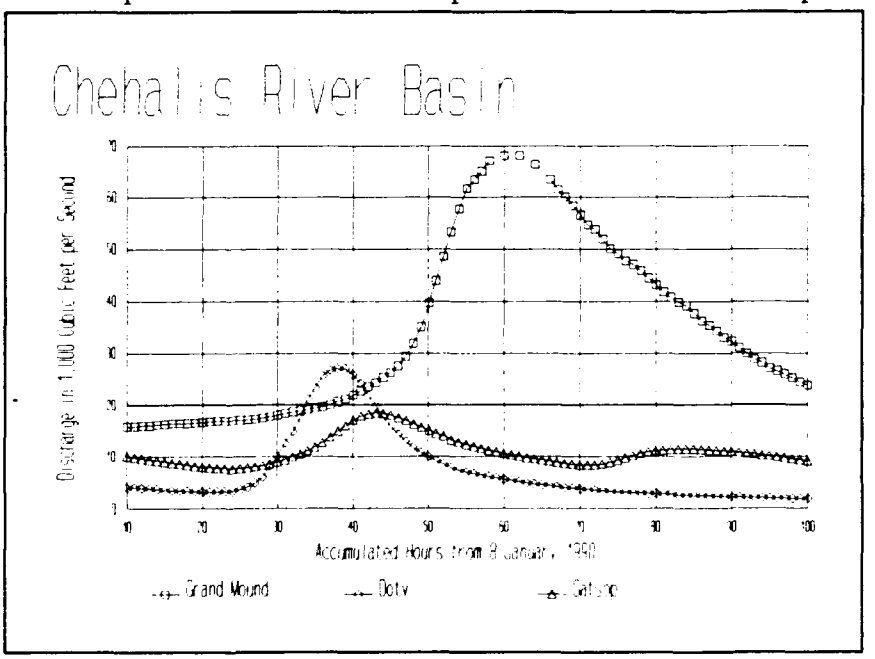


Figure 8. Chehalis River Basin Hydrographs

15. Aberdeen. The location of Aberdeen at the mouth of the Chehalis River makes low-lying areas vulnerable to high flows on the Chehalis River and high tides in Grays Harbor. The first indication that Aberdeen might have a flooding problem came from a high tide notice. At 3 p.m. on Monday afternoon, 8 January, the NWS issued a coastal flood watch:

> "The National Weather Service has issued a coastal flood watch for the low lying areas of the Washington coast.. including Aberdeen..Raymond ..and South Bend..near time of high tide around 11 AM Tuesday. The tide table prediction for Aberdeen at 1106 AM Tuesday is 12.2 feet and for Raymond at 1108 is 12.0 feet. The effects of wind.. heavy swells..low pressure..and river runoff from a strong cold front may increase the tide levels by 2.3 to 2.8 feet by 10 AM tomorrow. This would result in a high tide level approximately 14.5 to 15.0 feet at Aberdeen and 14.3 to 14.8 feet at Raymond.. Tidal overflow problems normally begin at Aberdeen at 13.5 feet and at Raymond at 14.1 feet. Serious flooding occurs at 14.5 feet at Aberdeen and 14.5 feet at Raymond. Persons should begin to take effective actions to protect property affected by high water."

At 11 p.m. on Monday, the NWS canceled the coastal flood watch, but reported that minor tidal flooding could still occur with the range reduced to between 14.2 and 14.7 feet at Aberdeen. Typically, high tides and peak Chehalis River flows do not coincide. Renewed warnings of coastal flooding began again on Tuesday as the abating storm began to re-intensify to threatening levels. Information bulletin No. 14 from the NWS reported that the peak stage at Aberdeen was observed at 10.9 feet at 0230 hours on 12 January. The observation includes the effects of tidal variations in Grays Harbor and was lower than the serious flood level of 14.5 feet. There was no report of flooding in Aberdeen either from the river, tide, or interior runoff. Flood watchers were expecting higher stages on the Chehalis River as the peak discharge reached Aberdeen. A more detailed storm and hydraulic study beyond the scope of this report would be needed to explain the behavior of the lower river above Aberdeen.

FLOOD DAMAGES

16. Flood Categories and Damages. Flood damages were obtained from field investigations, Damage Survey Reports, and personal interviews with homeowners, farmers, businessmen and Federal, state, county, city and public utility officials. Eyewitness accounts of flooding and reports of damage in local newspapers also were useful in identifying and quantifying flood damages. Flood damages were collected by subarea. Data on damages sustained in those areas that would be protected by the proposed Skookumchuck Dam Modification Project and the Salzer Creek Project are available in Economics Section back-up files.

a. Damage Categories. Flood losses and damages were determined for the following seven categories:

(1) Residential. Losses or damage include damage to nonfarm residential structures and contents, appurtenant buildings and grounds.

(2) Commercial. Damages include losses or damage to all properties, including inventory, structures and fixtures used in wholesale or retail business, trade or services.

(3) Public Facilities & Utilities. Public damages include inundation losses to schools, parks, roads, streets, bridges, and other property, including equipment and furnishings owned and operated by Federal, state, county, or local government units. Damage to all utilities such as electric, water, telephone, and sewer lines are included. Damages to buildings, grounds and equipment at the Lewis County Airport and Fairgrounds are also included in this category.

(4) Agricultural. In addition to losses of crops, land, and livestock, agricultural damages includes damages to farm dwellings, barns, and other appurtenant buildings and their contents.

(5) Emergency Aid. This category includes expenditures for preservation of life and property, such as clearance of debris and wreckage, emergency repair or temporary replacement of public facilities, evacuation assistance, temporary housing, Federal aid for flood fighting, rescue operations, police protection, and repair and restoration of damaged flood control works.

(6) Aircraft & Automobiles. This category includes losses or damages to cars and trucks throughout the basin, and airplanes that were flooded at the Lewis County Airport.

(7) Traffic Delays. Monetary losses due to delays and rerouting of highway traffic are included due to the closure of Interstate 5, U.S. Route 12, and State Route 507.

b. Flood Damages. The January 10, 1990 flood in the Chehalis River Basin caused an estimated $19,189,000 in damages, the highest on record. Flood-affected cities and their 1989 populations are: Centralia (11,840), Chehalis (6,320), Montesano (3,140), Elma (2,420), Bucoda (525), and Oakville (569). Residential damages were highest in Centralia and Chehalis. Residential damages throughout the basin totaled $4,313,000. Approximately 905 residential dwellings were damaged during the flood. Commercial damages were also concentrated in Centralia and Chehalis with Chehalis being the hardest hit. Significant damage was reported by 43 firms basinwide, and totaled $6,801,000. Public damages totaled $2,829,000. County, State, and Federal roads and the Lewis County Fairgrounds incurred the majority of these damages. Agricultural damages were $1,324,000 and included losses of 150 cattle and 42,000 fryers. Approximately 10,000 acres of agricultural land were flooded, including 4,000 acres of cropland. Emergency aid damages were $640,000, of which $485,000 was for temporary housing. The category of Aircraft & Automobile damages totaled $1,110,000, with aircraft losses representing $650,000 of the total. Losses associated with traffic delays totaled $2,172,000. Delay and rerouting costs due to the 4-day closure of I-5 represented $2,098,000 of this total. Total damages for the entire basin are summarized by category in table 3.

FORECASTS

17. River Forecasts. River forecasts originate from the Portland River Forecast Center of the NWS which furnishes them to the Seattle office of NWS. The Seattle office of the NWS transmits the forecasts nationally by way of a commercial communications satellite. The forecasts are received in the Reservoir Control Center at NPS directly from a satellite antenna and printed on the teletype data terminal. The first indication of the possibility of high water came on 8 January when the NWS issued a coastal flood watch at 3 p.m. The watch was continued at 5 p.m., but at 11 p.m. the

coastal flood watch was canceled. By the morning of 9 January, observed weather conditions indicated a renewed potential for flooding, and the NWS began a series of flood information bulletins. Pertinent data from these bulletins are summarized for two key gages, Skookumchuck at Centralia (table 4) and Chehalis at Centralia (table 5). Bulletin numbers are missing from the tables where forecasts applied to other river basins. There were no specific forecasts for the gage locations at Grand Mound and Porter. There were some general statements that implied flooding would cover a broad region. The first statement was in bulletin No. 4, "The worst flooding will be in the Chehalis River basin where it is forecast to go 7.0 feet above flood stage causing major damage." Bulletin No. 7 had the same statement with the forecast number changed to 8.0 feet and bulletin No. 8 had the forecast at 8.7 feet above flood stage. The stages refer to Chehalis River at Centralia which finally crested at 8.4 feet above flood stage. The Chehalis River crested 6.8 feet above flood stage at Grand Mound and approximately 6 feet above an estimated flood stage at Porter. Oakville probably experienced flooding of between 6 and 7 feet above flood stage. Forecasts are difficult to quantify for various reasons. River forecasts require continuous information on present and expected atmospheric conditions in the affected area. This information is difficult to obtain for a coastal region due to the lack of specific data on the moisture supply of an air mass over the Pacific Ocean. Forecasts are generally better at times when the storm is centered near the precipitation index stations; however, this is typically not the case. In addition,

Table 3 Summary of Chehalis River Basin Damages by Category, January 10, 1990 Event

CATEGORY	DAMAGES
Residential	$ 4,313,000
Commercial	6,801,000
Public Facilities & Utilities	2,829,000
Agricultural	1,324,000
Emergency Aid	640,000
Aircraft & Automobiles	1,110,000
Traffic Delays	2,172,000
TOTAL DAMAGES	$19,189,000

Table 4. Forecasts for Skookumchuck River at Centralia

◂-Flood Stage is 85 feet.

Bulletin	Transmitted Time	Transmitted Date	Observed Stage	Forecast:
#2	8 AM	9 Jan.	79.5	Cresting at 83 ft 10 AM 10 Jan.
#3	11 AM	9 Jan.	80.5	Cresting at 83 ft 10 AM 10 Jan.
#4	3 PM	9 Jan.	82.9	Cresting at 86 ft 10 AM 10 Jan.
#7	11:50 PM	9 Jan.	86.2	Cresting at 87 ft 4 AM 10 Jan.
#8	7 AM	10 Jan.	87.1	Cresting at this time.
			Falling below 85 ft by early on 11 Jan.	
#9	Noon	10 Jan.	87.0	Crested and falling.
			Falling below 85 ft by early on 11 Jan.	
#10	8 PM	10 Jan.	86.8	Crested and falling
			Falling below 85 ft at 4 AM Jan.	
#11	5 AM	11 Jan.	85.0	Down 1.8 feet.

Table 5. Forecasts for Chehalis River at Centralia

Bulletin	Transmitted Time	Date	Observed Stage	◂-Flood Stage is 65 feet. Forecast:
#2	8 AM	9 Jan.	63.1	Cresting at 68.5 ft late 10 Jan.
#3	11 AM	9 Jan.	63.4	Cresting at 70 ft late 10 Jan.
#4	3 PM	9 Jan.	64.4	Cresting at 72.0 ft 2 PM 10 Jan.
#7	11:50 PM	9 Jan.	70.8	Cresting at 73.0 ft 2 PM 10 Jan.
#8	7 AM	10 Jan.	73.3	Cresting at 73.7 ft 4 PM 10 Jan. Falling below 70 ft by 9 PM on 11 Jan. Falling below 65 ft by noon on 12 Jan.
#9	Noon	10 Jan.	73.3	Crested and falling. Falling below 70 ft by 9 PM on 11 Jan. Falling below 65 ft by noon on 12 Jan.
#10	8 PM	10 Jan.	73.0	Crested and falling. Will remain above flood stage through 11 January, falling below 65 ft around noon 12 Jan.
#11	5 AM	11 Jan.	70.8	Down 2.2 feet.
#12	9 AM	11 Jan.	69.4	Receding below 65ft noon 12 Jan.
#13	4 PM	11 Jan.	67.7	Receding below 65ft noon 12 Jan.

the storm center, direction, and travel speed can greatly affect the forecasts, which is also difficult to forecast with great precision. Therefore, a conservative approach is often used by NWS and should be taken conservatively by the public when using these forecasts to perform flood fighting, evacuation, or other flood related activities. Forecasts are furnished to information media as a public service for local residents. They are also furnished to public agencies to provide lead time to take defensive action before serious flooding occurs. Preventative actions include moving farm animals and equipment to higher ground, sandbagging where necessary and evacuating homes or business. All of these flood fighting activities occurred in the Chehalis basin during this event.

FLOOD FIGHTING

18. Flood Fighting. The Corps Emergency Operations Center dispatched the Chehalis flood fighting team for the Centralia area early morning on Tuesday, 9 January. Emergency operations are initiated when floodflows are forecast to exceed specified damage levels (table 6). The Corps sent 25,000 sandbags to the area on Tuesday afternoon. The National Guard was also activated early in the morning for search, rescue, and recovery operations. Traffic movement became restricted on 10 January. Local streets were

Table 6. Significant High Water Stages (in feet)

River	Station	Damage Stage Zero	Major
Skookumchuck	Pearl Street	85.0	89.0
Chehalis	Centralia	65.0	68.5
Chehalis	Grand Mound	12.5	16.5
Chehalis	Aberdeen	13.5	14.5

gridlocked due to the closure and detour from Interstate 5 that morning. The left bank of the Skookumchuck River has a levee upstream of Pearl Street that was both overtopped and outflanked during the flood. Both the Centralia and the Chehalis sewage treatment plants were put out of service, requiring unchlorinated discharge into the floodwaters. During the afternoon of the 10th, the Corps sent 30,000 sandbags to Montesano and 2,000 sandbags to Oakville. Grays Harbor County closed the Porter bridge at about 8 p.m. that evening. Just after midnight, on 11 January, the County ordered the evacuation of Oakville. Later that afternoon, pumping began at the Lewis County fairgrounds as a result of Chehalis river backwater on Salzer Creek. The water was higher inside the grounds than outside. Caution was necessary due to fuel that had leaked from flooded vehicles in the fairgrounds. By 12 January, the I-5 freeway had reopened for traffic. The southbound lanes were still slick from mud. Work continued on the repair of the levee at the airport. Other flood activities and details are recorded on Situation Reports that are on file in the Emergency Management Branch of Operations Division (see appendix B).

19. Flood Assessment. The cities of Centralia and Chehalis, as well as Lewis County, employed all their available resources during the flood emergency to protect property and provide for public safety. State of Washington departments were also active during and after the flood. An Interagency Hazard Mitigation Team met during 29-31 January 1990 at the State's Division of Emergency Management Office in Olympia. Additional flood observations and experiences were reported from members of this team. Discussion topics included modification of Skookumchuck Dam, fairground alternatives, Salzer Creek project, flood warning systems, and airport levee repairs. A flood warning and flood response plan, a levee protecting the fairgrounds, airport and I-5, and levees on the Skookumchuck River are receiving follow-on attention. Memoranda on these topics can be found in appendix A. Some flood warning procedures are already part of procedures that protect property when resources are available. For instance, flood fighters usually proceed with sand bagging efforts based on plans that slightly exceed forecasts. This flood's data can be used as an example to illustrate the time frame available for flood fighting efforts. Table 4 shows forecasted peaks and times for Skookumchuck River at Centralia. The first river stage forecast indicated that flood fighting should protect against a stage of 83 feet that may be reached within 22 hours. Seven hours later, flood fighters would see water at the top of their sand bags and a revised forecast would recommend that everything be built 3 feet higher within 15 hours. Nine hours later, the actual water level would again be up to the level of the sand bags and a revised forecast would recommend one foot higher. This moving target shows that flood engineers need to accomplish their flood work about twice as fast as the time allotted in the forecast and still have enough material on hand to go somewhat higher on a moment's notice. This type of concern for future conditions during the rising portion of flood discharges also weighs heavily in the minds of decision makers who may need to recommend the evacuation of people from their homes in flood prone areas.

20. Bibliography. Information concerning the data used in the preparation of this report can be obtained by contacting the Dept. of the Army, Seattle District, P.O. Box C-3755, Seattle, WA 98124-2255. Other data is on file in the District as tabulated below by Office Symbol and Title of file folder.

Office Symbol	Data Title
CENPS-EN-HH-HG	1110-2-1403a Flood Activities - W.Wash. Flood Data for January 1990, two folders of tabulated data used in this report.
CENPS-EN-HH-HC	Working File of high water marks on Skookumchuck River, China Creek, Salzer Creek, and Chehalis R. January 1990 Flood Inundation Map for Centralia and Chehalis Scale 1:1,000
CENPS-EN-PL-CP	Video Cartridges, Jan. 10, 1990 Flood: Vicinity of Centralia & Chehalis, Taken by Lewis County (2 hrs) Photographs, 3½X5 color prints, 5 envelopes; Fords Prairie, Skookumchuck, Harrison Ave., Plummer Lake, Riverview, Airport, Yardbirds, Fairgrounds, Bucoda, Dam, & Centralia. Photo slides, 35 mm in yellow plastic boxes; 15 boxes, same locations as photographs.
CENPS-EN-PL-ES	DP-327 Chehalis Basin Jan. 10, 1990 Flood January 1990 Flood - Newspaper Clippings
CENPS-EN-PL-PF	Working file on coordination activities
CENPS-PA	News clippings and other text: 360 Centralia 360 Floods General 360-5b Floods General Video Cartridges: Centralia and Chehalis Flood, Jan. 1990 (3) Chehalis River Flood - 1990 Chehalis R. TV and News Clips Photo slides, 35 mm in 3-ring binder: Disasters; Floods, Earthquake, Oil Spill

ADDENDUM

21. November 1990 Flood. Additional information was added to this report after a flood was observed in the Chehalis River basin on Thanksgiving weekend of November 1990. Flooding in the Centralia-Chehalis vicinity was not as great as the January 1990 event. Maximum discharges from the Satsop and Wynoochee Rivers and other local areas in the lower Chehalis basin were greater than the January 1990 flood. However, maximum runoff in the lower basin occurred earlier than the middle basin so water had already subsided in the lower Chehalis River prior to the arrival of flood flows from the middle basin. The November event is described in more detail below with a short description of the meteorology, hydrology, and flood damages.

a. Meteorology. Extremely heavy rainfall occurred in the Chehalis River basin during the Thanksgiving weekend in November 1990. A total of 6.1 inches was recorded for 5 days at the Centralia precipitation gage and 6.7 inches was recorded at the Cinebar gage near the Skookumchuck River. Aberdeen captured a new record of 7.02 inches for the 24-hour period ending at 8 a.m. on Saturday, 24 November. The previous record was 5.46 inches on 2 December 1977, according to records dating back to 1891. The Olympia weather station set some new records also. The 24-hour period from 3 p.m. Friday, 23 November, to 3 p.m. Saturday, 24 November, was the wettest 24-hour period on record at this station. The rain total for the storm period was 5.90 inches, almost an inch greater that the old record of 4.93 inches on February 8-9, 1951.

b. Hydrology - Middle Basin. The Skookumchuck River rose to a crest of 10.30 feet on 24 November at the Vail streamgage. Further downstream at Pearl Street, the river crested at 86.65 feet at 8 a.m. on 25 November. The maximum discharge of 9,200 cfs at Pearl Street is approximately a 25-year event. The Chehalis River rose to a crest of 71.42 feet (48,400 cfs) on 25 November at the Centralia streamgage. Below the confluence with the Skookumchuck River, the Chehalis river rose to a crest of 18.12 feet at the Grand Mound streamgage, within 1.2 feet (lower) of the January 1990 flood. The maximum discharge of 48,000 cfs was approximately a 30-year event.

c. Hydrology - Lower Basin. The Satsop River rose to a crest of 35.75 feet at the Satsop gage on 24 November at 11 a.m. The crest is 4.3 feet higher than the January 1990 flood and the maximum stage represents a discharge of 38,200 cfs which is approximately a 10-year event. The Wynoochee River, controlled by Wynoochee Dam, rose to a crest of 18.21 feet at the Black Creek gage on 24 November at 6 p.m. The maximum stage represents a discharge of 21,700 cfs which is approximately a 20-year event. High tributary flows had a chance to drain downstream to Grays Harbor before the flood flows from upstream arrived in the vicinity of Montesano and Aberdeen.

d. Flood Damages. Damages were reported from a variety of newspapers while the flood was in progress. Unsubstantiated newspaper observations are repeated below to serve as an overview of conditions experienced along the rivers:

> "Thirty roads were closed in Lewis county for the weekend. Interstate 5 was congested with traffic in the Centralia-Chehalis area, slowed by some water on the northbound roadway and minor accidents. Salzer Creek flooding caused some homeowners to evacuate. Four families in Bucoda were evacuated. A Red Cross emergency center was opened in a Chehalis Church and another opened in a Salvation Army headquarters in Centralia for several families flooded out of their homes. Sandbags saved 150 homes in Centralia from the flooding Skookumchuck River. Water damages were reported in Aberdeen, Hoquiam, and rural areas of Grays Harbor county. A home was destroyed in one of a number of slides on Wynoochee Valley Road. Damage from a flash flood that drenched Aberdeen and a swollen river that submerged the Oakville area could exceed several million dollars."

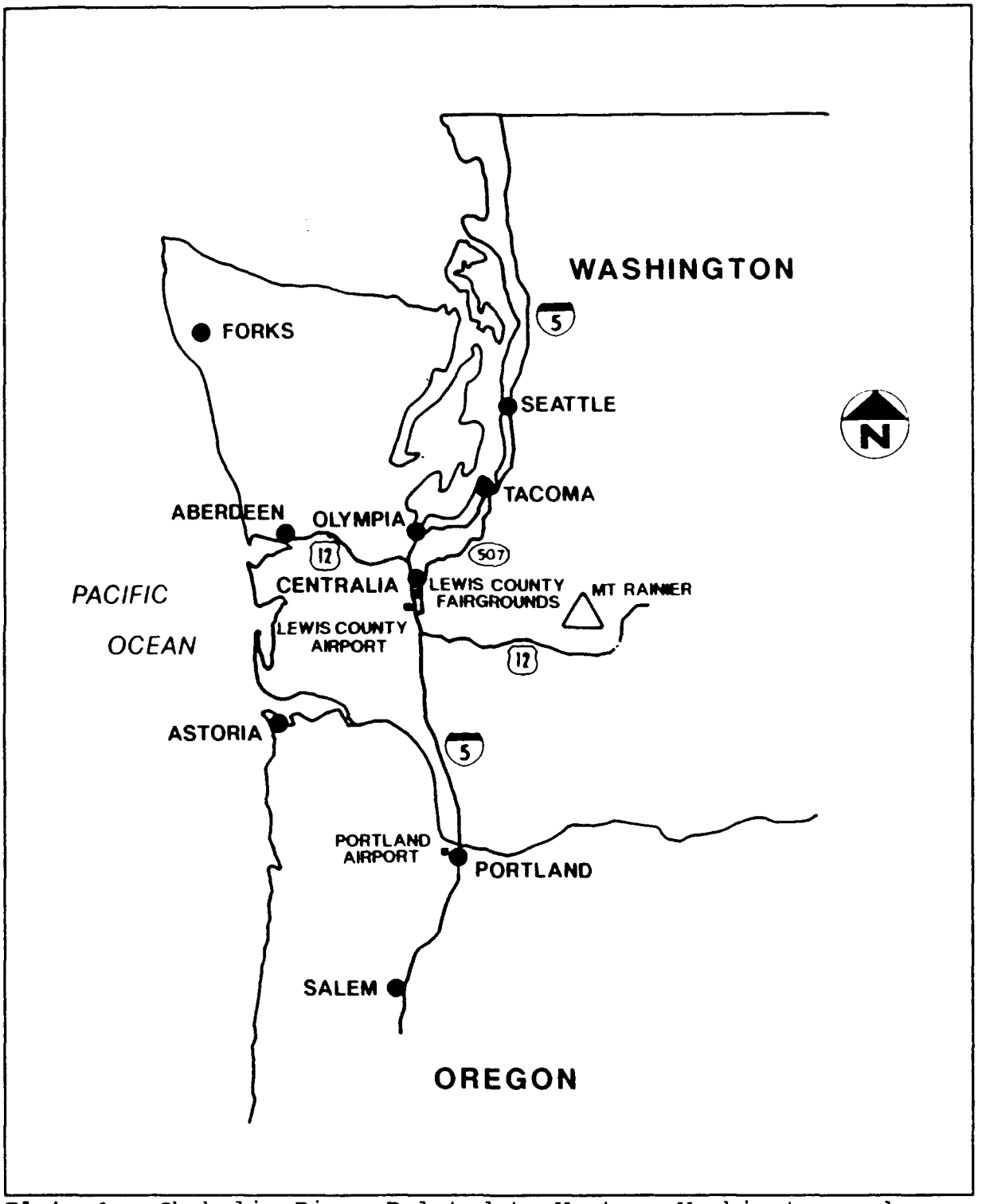


Plate 1. Chehalis River Related to Western Washington and Oregon

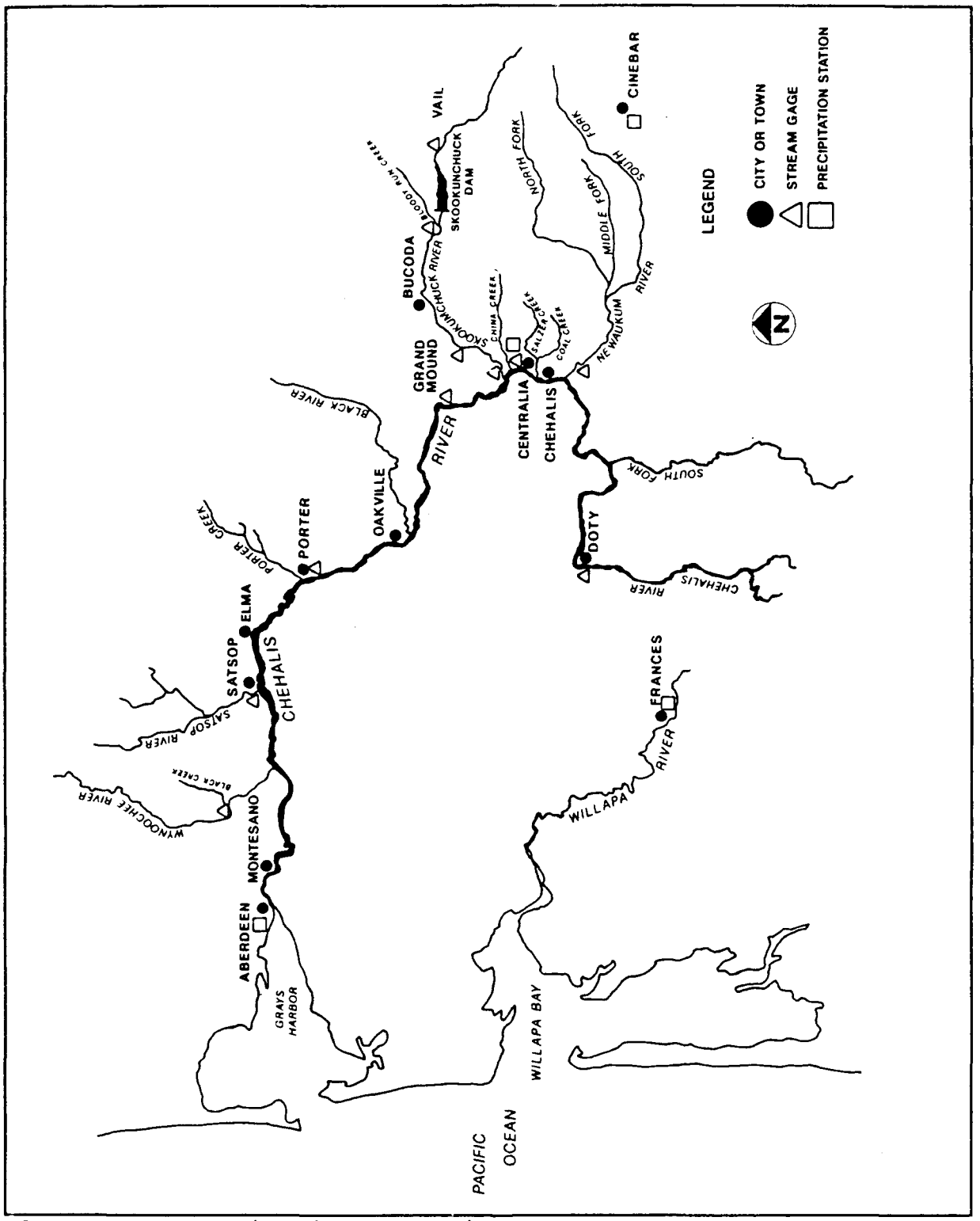


Plate 2. Chehalis River Location of Towns and Gages

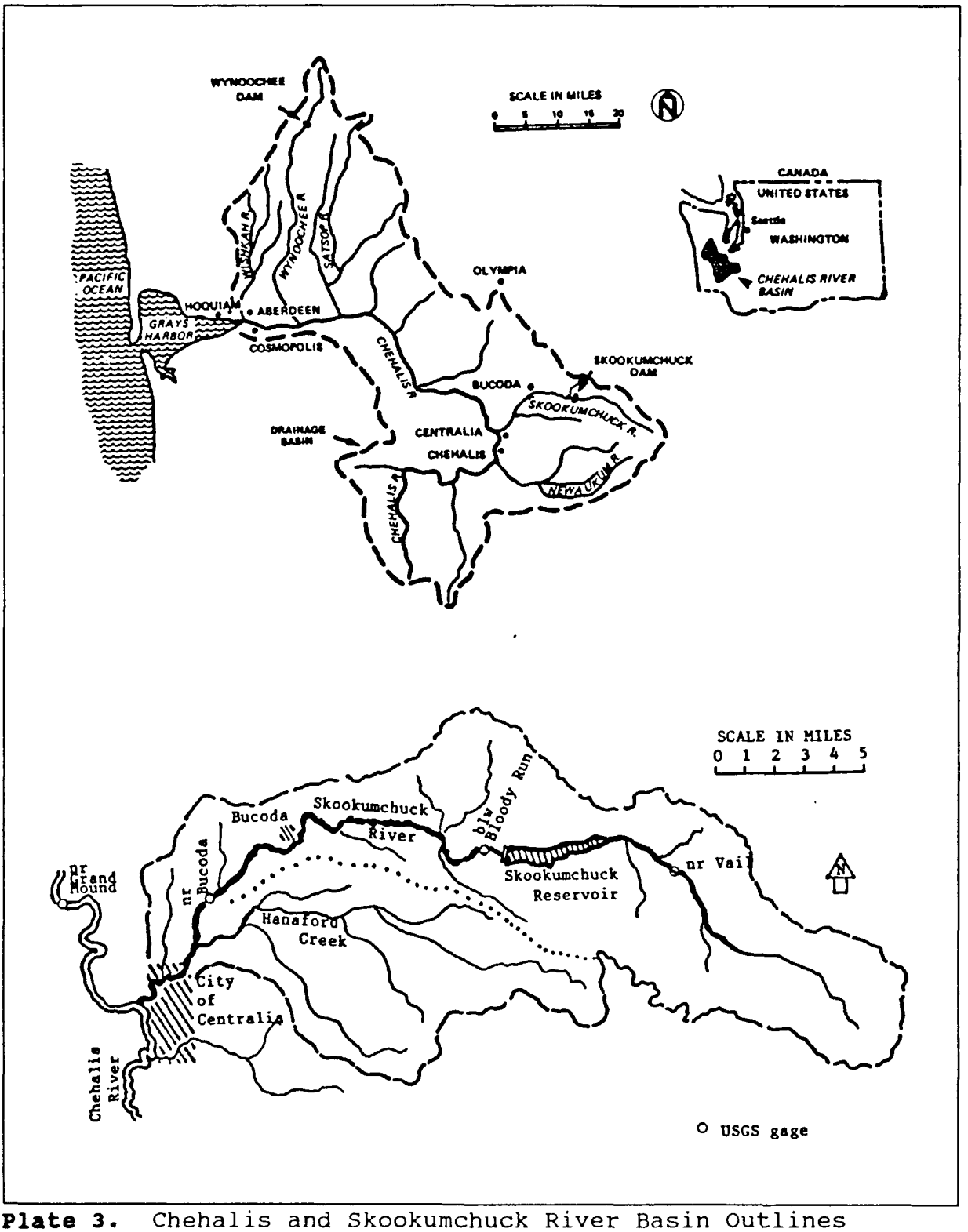


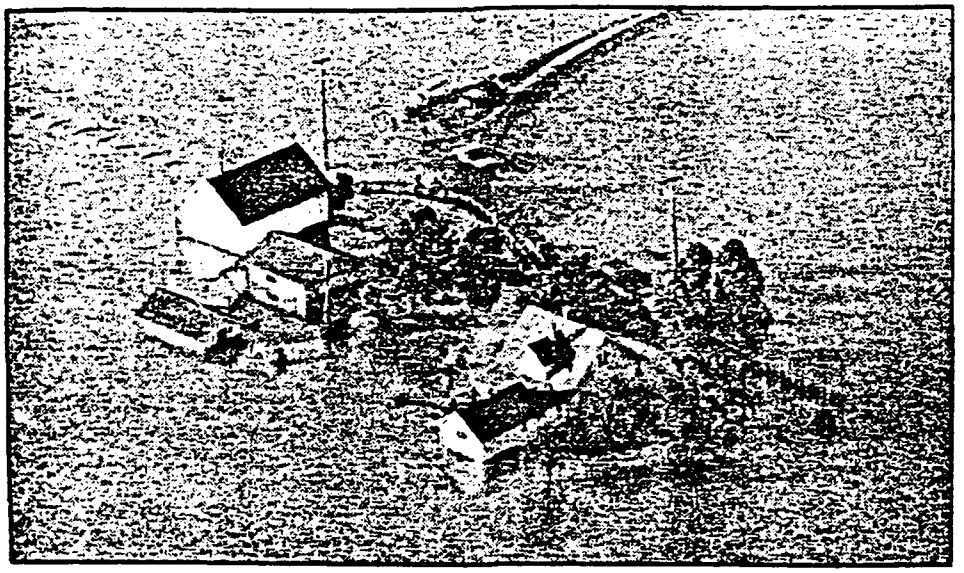
Plate 3. Chehalis and Skookumchuck River Basin Outlines

APPENDIX A

HAZARD MITIGATION OPPORTUNITIES IN THE STATE OF WASHINGTON

SUPPLEMENTAL REPORT OF THE INTERAGENCY HAZARD MITIGATION TEAM

FEMA-883-DR-WA



FEDERAL EMERGENCY MANAGEMENT AGENCY
REGION X

JANUARY 31, 1991

SUPPLEMENTAL FLOOD HAZARD MITIGATION REPORT

In Response to the November 26, 1990
Disaster Declaration
State of Washington

FEMA-883-DR-WA

A SUPPLEMENTAL REPORT COVERING:

San Juan, Kitsap, Pierce, Thurston, Lewis,
Grays Harbor, Pacific, Wahkiakum, Mason,
Chelan, Yakima, Kittitas, Island, Jefferson, Clallam

Prepared by the Region X
Interagency Hazard Mitigation Team

FEDERAL AGENCIES

Federal Emergency Management Agency
U.S. Army Corps of Engineers
Department of Housing and Urban Development
National Weather Service
Small Business Administration
Soil Conservation Service
United States Geological Survey
U.S Fish and Wildlife Service
Federal Highway Administration
Environmental Protection Agency
U.S. Forest Service
Bureau of Indian Affairs
Farmers Home Administration

WASHINGTON STATE AGENCIES

Department of Community Development,
Divisions of Emergency Management and Growth Management
Department of Ecology
Department of Natural Resources
Department of Corrections
General Administration
Department of Fisheries
Department of Wildlife
Department of Transportation

COUNTIES AND MUNICIPALITIES

Pierce County, Lewis County, Kitsap County, Kittitas County,
Jefferson County, Pacific County, City of Aberdeen

JANUARY 31, 1991

TABLE OF CONTENTS

INTRODUCTION

This report is a supplement to the report entitled: Hazard Mitigation Opportunities in the State of Washington. The earlier report was released by the Interagency Hazard Mitigation Team (IHMT) on January 9, 1991.

The January 9, 1991 report presented hazard mitigation recommendations for Whatcom, Skagit, Snohomish and King counties based on IHMT meetings held on December 5th through the 7th, 1990 in Mt. Vernon, Washington. These counties had been declared disaster affected counties by a Presidential Declaration on November 26, 1990.

This supplemental report includes hazard mitigation recommendations for those counties which were added in December 1990 to the earlier Presidential disaster declaration. They include the counties of San Juan, Island, Kitsap, Jefferson, Clallam, Pierce, Thurston, Lewis, Mason, Grays Harbor, Pacific, Wahkiakum, Chelan, Kittitas and Yakima. This IHMT supplemental report presents the IHMT recommendations from the January 9th and 10th meetings held in Lacey, Washington.

This supplemental report also includes additional work elements and recommendations for the initially declared counties of Whatcom, Skagit, Snohomish and King. These work elements were submitted after the completion of the January 9, 1991 report.

DISCUSSION OF DAMAGES FOR ADD-ON COUNTIES

The add-on counties were not significantly damaged by the first rain storm that occurred between November 7th and the 14th of 1990. However, the second rain storm, occurring between November 20th and the 24th was accompanied by high winds and not only caused severe flooding of creeks and rivers, but also damaged bulkheads, eroded beaches and damaged properties in the supplemental counties.

In Western Washington counties, floods damaged the same areas that have flooded before, for example the Centralia-Chehalis area. On the other hand, the three Eastern Washington counties (Chelan, Kittitas and Yakima) experienced severe flooding for the first time in many years.

The types of damages included bulkhead failures and shoreline erosion, flooding of homes, and significant damages to private roads.

WORK PROGRAM ELEMENT NO. SWE-1

TITLE: Bulkhead Failures and Shoreline Erosion

DESCRIPTION OF THE PROBLEM:

Many bulkheads protecting shoreline properties were damaged by the November 1990 rain/wind storm event. Property owners want to repair or re-construct these damaged bulkheads but do not have sufficient information for proper repair or re-construction. Local officials should provide technical assistance workshops on the proper methods of repairing or re-constructing the damaged bulkheads.

BACKGROUND:

Over the years, these bulkheads were constructed by individual property owners, with no common standards of construction or materials. Some of the bulkheads were connected and inter-dependent.

ALTERNATIVE SOLUTIONS:

1. Do not reconstruct the bulkheads.

2. Reconstruct the bulkheads to individual standards as was previously done.

3. Reconstruct to uniform contemporary design standards.

RECOMMENDATIONS:

By conducting local workshops, local officials could provide technical assistance. Guidelines and construction techniques appropriate to shoreline protection should be furnished by State and Federal agencies listed below. Since many cities and counties do not have people on their staff who have knowledge of retaining structures, the workshops should be conducted by soils or structural engineers with knowledge and experience in retaining wall design. The USACE also has brochures that would be helpful.

LEAD AGENCIES:

Local Building Officials and/or Local Emergency Management

SUPPORT AGENCIES:

USACE, SBA, WSDOE, WSDCD/DEM

POTENTIAL FUNDING SOURCES:

Minimal funding needed.

SCHEDULE (BY RECOMMENDATION NUMBER):

Immediately

WORK PROGRAM ELEMENT NO. SWE-2

TITLE: Gibraltar Slide Area, Fidalgo Island, Skagit County

DESCRIPTION OF THE PROBLEM:

This slide area appears to be renewal of slide activity within a 2000 feet zone that cuts Gibraltar Road and two sub-parallel residential streets on Fidalgo Island, directly affecting thirty residential structures, two of which were critically damaged. Actual slide displacements took place after a series of heavy October and November, 1990 rain storms that saturated the soil and underlying recessional sand deposited during the glacial retreat. This sand horizon is approximately 100 to 150 feet thick and is composed of fine grained silty sand with scattered 1-3 inch pebbles and cobbles. The sand overlays a typical hard, compact glacial till which is exposed approximately 20 feet above high tide elevation. The beach and inter-tidal zone was not visible at the time of observation, but may be composed of till and inter-bedded lenses of typical glacial clay.

The slide appears to be rotational with the actual slide plane or planes not being clearly exposed and may extend to the low tide zone. The slide surface is characterized by numerous cracks with vertical displacements varying from a few centimeters to more than a meter.

Several trees on the steeper portions of the slope display "pistol grip" trunks indicating a slow beach-ward creep.

Because of the fine grained, silty character of the recessional sand and the combined slopes of this area, saturation of the sand horizon and subsequent greasing of possible clay units within the underlying till require extensive periods of rainfall with considerable lag time between rain storm activity and actual slide event.

BACKGROUND:

Geo-Engineers, a consulting firm, in their letter of January 10, 1991 to Skagit County Department of Emergency Management stated:

> "The area of the present land sliding lies within an ancient landslide complex that had not been previously recognized. The Washington State Department of Ecology Coastal Zone Atlas for Skagit County depicts two relative small landslide areas along the shoreline, but does not indicate the presence of the large, ancient landslide complex. This area of shoreline is designated as "unstable" in the Coastal Zone Atlas, apparently due to the steepness of the bluff and the erodibility of the sandy soils rather than any inferred large scale landslide potential."

ALTERNATIVE SOLUTIONS:

1. Stabilize the slide zone by de-watering the sand above the slide planes. Rebuild the existing roads and provide a storm water drainage system that will not contribute to the recharge of the permeable sand horizons. Retrofit all existing dwellings to require tight lining drainage from impervious surfaces including roofs, driveways, decks, patios, side walks and footing drains, to an approved community storm water drainage system.

2. The only other alternative is to require this slide area and adjacent developments with similar geologic conditions to be abandoned or abated.

RECOMMENDATIONS:

1. Monitor landslide physical characteristics, movement, static water levels in slide prism, and local rainfall activity.

2. Conduct additional geologic investigations of the landslide area and adjacent zone to evaluate its causes and possible mitigation.

3. Design and install storm water control system that will restrict all impervious surfaces of road, roofs, driveways, etc. from contributing to sub surface water discharge within the slide area.

4. Create a "sensitive area zone" and adopt storm water control requirements for existing housing and new developments.

5. Prevent additional storm water from entering existing and future cracks and fissures in the slide area.

6. Control development in hazardous areas.

LEAD AGENCIES:

Skagit County

SUPPORT AGENCIES:

WSDCD/DEM, FEMA, WSDNR

POTENTIAL FUNDING SOURCES:

WSDCD/DEM Section 404, FEMA Section 406, Skagit County

SCHEDULE:

Immediately

WORK PROGRAM ELEMENT NO. SWE-3.

TITLE:

Hidden Valley Subdivision

DESCRIPTION OF THE PROBLEM:

The Nisqually Glacier is depositing a considerable volume of sand, gravel, and cobbles in the Nisqually River. This sediment is raising the bottom of the riverbed which in turn is causing the channel to meander and braid. As a result of these processes, channels have diverted flow through the Hidden Valley Subdivision. Portions of the subdivision are now river bottom lands and others are imminently threatened. The PUD power, telephone, water system, roads, and most of the drainfields have been wiped out. Any future investment in the area is subject to inevitable damage. Reoccupancy of this area would place residents in a life-threatening situation.

BACKGROUND:

Hidden Valley was platted in the early 1960's. At the time of the November 1990 flood, there were 12 full time residences, about 20 to 25 summer cabins, and approximately 50 vacant lots. The subdivision area was largely covered with a fairly mature stand of timber.

By 1984 the area was recognized as a hazardous area. In 1986, a levee was built which had confined the river to the old channel, but in January 1990, sediment within the old channel redirected the river over and through this revetment and into a deserted channel near Wold Road and Wasson Way. By November 1990, this channel had been filled with an estimated 100,000 cubic yards of sediment. The river jumped this reclaimed channel during the Thanksgiving 1990 flood, traversing subdivision roads, carrying a wide variety of debris (i.e. rock, silt, logs, houses, power poles) and depositing these materials randomly throughout the site. Not all homes were destroyed. Many were only impacted by the lack of road surfaces and access.

The predisaster wooded environment has largely been destroyed as the subdivision is crisscrossed by river channels and laden with debris. Other predisaster values will disappear as existing tree stands die because the deposited silt is smothering the tree roots.

The subdivision was not designated as a Special Flood Hazard Area on the Flood Insurance Rate Map prepared by FEMA-NFIP.

ALTERNATIVE SOLUTIONS:

1. Reoccupancy prohibition: Assemble all available resources and offer a

percentage of assessed value to all affected property owners in exchange for a quit claim to land or possibly only for a quit claim to road and utility access.

2. Restoration without mitigation: Restore roads and utilities and clear the old Nisqually Channel, and build an expanded dike to keep the river in the old Nisqually Channel. This would cost an estimated $500,000 to restore roads and utilities, $500,000 to restore dikes and channels, and an annual maintenance cost of $200,000 to remove 100,000 cubic yards of sediment every year. Because of the dynamic nature of the river at this cross section, these measures should not be considered permanent.

3. Restoration with mitigation: The Nisqually River has permanently changed course. To reopen the subdivision and assure that residents will be reasonably safe from a future direct assault, the river would either have to be:

    a. Redirected to its predisaster channel. To assure that the channel remains in the old channel protective structures would have to be built, or

    b. Bridged to offer access to the undamaged dwellings and undeveloped parcels. Protective structures to protect existing and the new development, and keep the river in the new channel would have to be constructed. As with the first alternative, annual maintenance (dredging) would result in very high life cycle costs.

Water, and septic systems must also be restored.

It is estimated the above mentioned courses of action would result in costs exceeding the value of both existing and projected development by many times.

RECOMMENDATIONS:

It is recommended that Alternate Solution No. 1 (Reoccupancy prohibition:) be adopted.

Under this program it is necessary that all funding sources, including the following, be evaluated for application to this project:

1. Purchase as a result of this disaster through the NFIP Section 1362 funds: (Very few structures had flood insurance and only one of these was damaged)

2. Purchase as a result of future disasters through the NFIP Section 1362 funds: (Isolated, but yet undamaged structures may buy flood insurance

even though unoccupied. With destruction being imminent, claims and possible purchase may be possible as the river continues to claim property. Policies become effective with 5 days of purchase, and occupancy is not a condition of a claim.)

3. Public Assistance Section 406 funds. (Public assistance funds need not be used to reconstruct damaged facilities. The County and PUD can exercise the alternate project program and use Section 406 funds, discounted 10%, to buy out the property owners).

4. Appraise timber value (The dying timber has a salvage value).

5. Land & Water Conservation Funds. (There are limited funds available for purchasing lands with recreational values.

6. Community Development Block Grants (CDBG). (These funds are highly competitive, but their availability should be researched)

7. SBA Loans. (The year around residents of damaged homes may be eligible for SBA assistance.)

8. PL 93-288, Section 404. (These hazard mitigation funds are available at a 50% Federal/25% State/25% Local match, and can be used to purchase property should this purchase be cost effective and supported by the State Flood Hazard Mitigation Document. (The use of HMG funds to aid private interests may not be legal under the Washington State Constitution - see Work Element No. 11 in the IHMT Report covering the four northern counties dated January 9, 1991)

9. Possible purchase by the U.S. Forest Service or the National Park Service.

LEAD AGENCIES:

Lewis County

SUPPORT AGENCIES:

WSDCD/DEM, FEMA, WSDOE, USFS

POTENTIAL FUNDING SOURCES:

To be determined

SCHEDULE:

Immediately

WORK PROGRAM ELEMENT NO. SWE-4

TITLE: Rural Development Flood Damage

DESCRIPTION OF THE PROBLEM:

1. Many "new" developments in rural floodplains have been built in apparent disregard of floodplain regulations and building standards.

2. Recreation and year-round properties have been sold to unsuspecting buyers who are not informed of flood risks or other natural hazards.

3. Irrigation reservoir water release can not privide incidental flood protection when release is necessary because of full reservoirs.

BACKGROUND:

Recent rural floodplain site investigations revealed flood damaged properties built in special flood hazard areas on the Yakima and Teanaway River in Kittitas County. Evidently, recent property owners were not informed of flood risks before buying and/or developing these properties.

ALTERNATIVE SOLUTIONS:

1. Enforce existing floodplain regulations.

2. Increase FEMA's Community Assessment Visits.

3. Increase public awareness of flood hazards on the Yakima and Teanaway Rivers.

4. Inform concerned persons of Bureau of Reclamation's irrigation reservoir operations.

5. Suspend Kittitas County from National Flood Insurance Program for non-conformance.

6. Review and improve county's capability to warn, evacuate and provide direction and services to citizens in these areas.

RECOMMENDATIONS:

1. Enforce the floodplain regulations.

2. Increase public awareness of flood hazards along the Yakima and Teanaway Rivers and of the Bureau of Recreation's operations of irrigation reservoirs. Require disclosure by Real Estate Agents and Sellers.

3. Review and improve the county's capability to warn, evacuate and provide direction and services to citizens in these areas.

LEAD AGENCIES (BY RECOMMENDATION NUMBER):

1. Kittitas County; FEMA/NFIP
2. Kittitas County Emergency Management and Bureau of Recreation
3. Kittitas County Emergency Management/Sheriff's Office;

SUPPORT AGENCIES:

1. WSDOE
2. WSDCD/DEM
3. WSDCD/DEM

POTENTIAL FUNDING SOURCES (BY RECOMMENDATION NUMBER):

1. Existing County and State Programs (if required)
2. Kittitas County
3. Kittitas County and the Bureau of Reclamation

SCHEDULE (BY RECOMMENDATION NUMBER):

1. Immediately
2. Before the next flood season (Spring or Fall of 1991)
3. As soon as possible.

WORK PROGRAM ELEMENT NO. SWE-5

TITLE: Recurring Floods in Centralia and Chehalis Area

DESCRIPTION OF THE PROBLEM:

The Centralia and Chehalis area in Lewis County is subject to flooding from the Chehalis, Skookumchuck, Newaukum rivers and their tributaries, China, Salzer, Dillenbaugh and other creeks. Although the November, 1990 floods in Centralia and Chehalis were not as large and damaging as in the January, 1990 flood, some of the most floodprone areas did receive damage again, for example, along Harrison Avenue in Centralia and the apartments along Chehalis Avenue in Chehalis.

Flood control structures in the area include: (1) a dam on the Skookumchuck River which provides incidental flood control benefits for Centralia; (2) a levee segment on the Skookumchuck River which protects a portion of Centralia; and, (3) a levee which protects the Chehalis-Centralia airport site.

BACKGROUND:

Almost annually, the Centralia-Chehalis area floods. Developed prior to the floodplain's identification, these urban areas are extremely vulnerable. Proposed structural flood controls cannot be implemented without matching local funds, yet a systematic and coordinated flood control program is required to avoid future damage.

ALTERNATIVE SOLUTIONS:

1. Encourage all homeowners and business-owners who receive flood damage to flood-proof their homes and businesses. Perform flood audits on selected structures.

2. Improve flood-warning and flood-response in the Centralia-Chehalis area.

3. Determine feasibility of structural projects to reduce flooding, including:

   a. A project to reduce flooding in the lower Salzer Creek Valley;

   b. A project to reduce flooding along the Skookumchuck River;

   c. A project to reduce flooding along China Creek;

   d. A project to reduce flooding in the Riverside Road area; and,

   e. Other potential projects.

RECOMMENDATIONS:

These alternatives are interdependent and should be implemented simultaneously:

Alternative 1: The State government with FEMA support will provide leadership (e.g., conduct workshops in the area) to inform homeowners and business-owners of the advantages and opportunities of flood-proofing.

Alternative 2: The Federal government will aid the local governments and individuals in improving their flood warning and flood response system.

Alternative 3: All potentially feasible structural projects should be investigated, and their costs, benefits and impacts thoroughly researched.

a. The Corps of Engineers is currently studying flooding problems along the lower Salzer Creek;

b. The Corps of Engineers is currently studying flooding problems along the Skookumchuck River.

c. The City of Centralia should address the China Creek flooding problem.

d. The City of Chehalis should address the Riverside Road problem.

LEAD AGENCIES (BY RECOMMENDATION NUMBER):

1. WSDCD/DEM

2. USACE and NWS (for flood warning only)

3. a. USACE

   b. USACE

   c. City of Centralia and Lewis County

   d. City of Centralia and Lewis County

SUPPORT AGENCIES (BY RECOMMENDATION):

1. USACE

2. Cities of Centralia and Chehalis and Lewis County

3. a. Centralia, Chehalis and Lewis County

   b. USACE--Technical Support

   c. USACE--Technical Support

POTENTIAL FUNDING SOURCES (BY RECOMMENDATION NUMBER):

1. WSDCD/DEM; FEMA Section 404

2. USACE-- Section 205

3. a. USACE-- Section 205 + State and Local match

   b. USACE-- Section 205 + State and Local match

   c. Centralia and/or WSDCD/DEM Section 404 + State and Local match

   d. WSDCD/DEM Section 404 + State and Local match.

SCHEDULE (BY RECOMMENDATION NUMBER):

1. On-going FEMA program, will be completed by January, 1991.

2. On-going study, will be completed in May, 1991

3. a. Salzer Creek Project: Feasibility Study will take two years, construction about two years.

   b. Skookumchuck River Project: Feasibility Study will take two years, construction about two years.

   c. Approximately two years to study and complete a small project.

   d. N/A

WORK PROGRAM ELEMENT NO. SWE-6

TITLE: Flood Hazard Disclosure

DESCRIPTION OF THE PROBLEM:

Until flooding occurs, many owners are unaware that their property is located in a floodplain. Floodplain property is hazardous and requires special development; if the land's floodplain status is not known, inappropriate development of these properties may occur. Recreation and year-round properties have been sold to unsuspecting buyers who are not informed of flood risks or other natural hazards.

BACKGROUND:

Floodplains are areas which may be subject to flooding. For regulatory purposes, floodplains with a one percent chance of flooding within a given year (one hundred year frequency flood) have been determined. On FEMA maps, floodplains are designated as Special Flood Hazard Areas. Used by State and local governments to regulate land use, FEMA maps are readily available to, buyers, sellers, and realtors. However, no law requires sellers, buyers, or their agents to determine or disclose a property's floodplain status.

Property owners and their agents should be required to disclose a property's flood potential and/or its location within a Special Flood Hazard Area.

RECOMMENDATIONS:

A flood hazard disclosure bill should be presented to the 1991 State Legislature. The bill should require that property sellers and/or their agents, prior to sale, indicate if a property is situated in a Special Flood Hazard Area on a current FEMA map.

The disclosure should also require a seller to indicate if the property is within a designated floodway, and how to determine local floodplain management ordinance requirements. County Assessors should also be required to include floodplain classification on property records and tax accordingly.

LEAD AGENCIES:

WSDOE for the IHMT

SUPPORT AGENCIES:

None

POTENTIAL FUNDING SOURCES:

None Required

SCHEDULE:

1991

WORK PROGRAM ELEMENT NO. SWE-7

TITLE: Standards for Non-Dedicated Roads in Private Development

DESCRIPTION OF THE PROBLEM:

A number of private developments are improperly located on floodplains. These developments do not properly maintain roads or provide adequate drainage, because road and drainage standards do not exist or are not enforced.

BACKGROUND:

Many developments in hazardous locations have built and maintained private roads that do not meet minimum county standards. Because they do not meet standards, they cannot be accepted as public (county or city) right-of-ways, are often costly to maintain, and prone to damage, and often are not eligible for repair and restoration funding after a disaster declaration.

ALTERNATIVE SOLUTIONS:

Road construction in private developments should be regulated by local ordinance. Specific construction standards should be enforced by county inspectors, the same as county roads. To cover repair and maintenance of disaster damaged private roads, the county should require bond from developers or property owners.

RECOMMENDATIONS:

1. Local government should adopt standards and regulations for private roads and enforce them.

2. Local government should offer property owners methods for bringing private roads to county standards.

3. With government assistance, large developments should consider formation of Local Improvement Districts (LIDs) to cooperatively improve existing roads.

LEAD AGENCIES:

Local Governments

POTENTIAL FUNDING SOURCES:

Local Improvement District for Road Improvement

SCHEDULE:

1991

WORK PROGRAM ELEMENT NO. SWE-8

TITLE: Construction Standards in Forest and Park Lands

DESCRIPTION OF THE PROBLEM:

Throughout Federal and State forest and park lands, roadways, culverts, ditches, trails and facilities were damaged. Flood losses in forests, parks, and habitat areas are expected to exceed $20 million. It is not known whether facilities in these areas were built to adequate standards or in compliance with existing floodplain regulations.

ALTERNATIVE SOLUTIONS:

1. Enforce existing regulations and standards.

2. Review and improve park and forest land design and construction standards.

3. Increase agency awareness of flood loss problems in forest and park area.

4. Revise forest and park management plans to reflect sound floodplain management.

5. Accept losses and do nothing.

RECOMMENDATIONS:

1. Enforce existing regulations and standards.

2. Determine whether construction activities are appropriate within the context of sound floodplain management. Review damages to determine if revised construction standards might reduce facility losses.

2. Adopt design and construction standards as needed for forest and park land construction and facilities.

3. Revise forest and park management plans to reflect sound floodplain management.

LEAD AGENCIES:

USFS / NPS / WSDNR

POTENTIAL FUNDING SOURCES:

Agency Budgets

SCHEDULE:

1991-1992

WORK PROGRAM ELEMENT NO. SWE-9

TITLE: Flood Damage Repair Work

DESCRIPTION OF THE PROBLEM:

Local governments are responsible for emergency measures to protect life and property immediately following a flood event. A declaration of emergency by the local government grants them additional authority to do emergency work in or around streams to resolve the immediate problem. In addition to the emergency nature of the work, some restorative work is done without the requirement to follow the normal permit procedures, by considering the work as maintenance. When work is proposed in or near rivers, authorizations including those under the following programs are required: Shoreline Management Act, Hydraulics Project Approval and Flood Hazard Prevention Ordinance.

Agencies responsible for administering these programs are concerned that the best solution is not being followed under the authority of emergency repair and maintenance. In particular, the Interagency Hazard Mitigation Team evaluates the problem and arrives at a proposed solution after the emergency or maintenance work has already commenced and it is not the best solution and may in fact be in conflict with requirements of the programs. This type of restorative work could contribute to increased resource damage. There are also concerns that work defined as "maintenance" may involve new construction or improvements which should be subject to hydraulic or environmental analysis.

ALTERNATIVE SOLUTIONS:

1. Continue to follow existing procedures.

2. Re-convene the Emergency Activities in Watercourses Committee to address emergency and maintenance work completed, following a flood event.

3. Form a committee composed of representatives of the agencies responsible for these programs, to develop guidelines for local governments to follow.

RECOMMENDATIONS:

Alternative No. 3. Form a committee of representatives of the affected agencies to develop a procedure and guidelines for local governments to follow in performing post flood emergency repair work. Prepare, print and distribute copies of a brochure describing the procedures to follow.

LEAD AGENCIES (BY RECOMMENDATION NUMBER):

WSDOE

SUPPORT AGENCIES (BY RECOMMENDATION):

WSDCD/DEM, WSDOF, WSDOW, USACE, WSAC

POTENTIAL FUNDING SOURCES (BY RECOMMENDATION NUMBER):

None Required

SCHEDULE (BY RECOMMENDATION NUMBER):

November 1, 1991

WORK PROGRAM ELEMENT NO. SWE-10

TITLE: Additional Flood Issues to be included in State Flood Mitigation Document.

DESCRIPTION OF THE PROBLEM:

In reviewing the State Flood Mitigation Program, many far reaching issues need to be addressed. Some of these issues were examined in Work Element No. 8 of the *Hazard Mitigation Opportunities in the State of Washington* principal document, presented by the Interagency Hazard Mitigation Team on January 9, 1991.

The three topics addressed below (water courses, storm water, and sediment) should be considered in conjunction with Work Element #8.

6. Watercourses.

This was briefly discussed in section 2.d. of Work Element No. 8 of the principal document.

During a flood event, local governments provide emergency life and property protection, and State or Federal resource agencies are responsible for protection of fish and wildlife resources and habitats. In quick-response situations, inadequate communication between these entities can frustrate work in or around streams, leaving unnecessary damage and facilities susceptible to damage in future events. Structures, residents, and fish and wildlife habitats can be threatened as a result of conflicts in goals and emergency activities of local governments and resource agencies.

As a result of a 1986 mitigation recommendation (FEMA-757-DR), an Emergency Activities in Watercourses Committee was established to resolve these conflicts. Chaired by the WSDCD/DEM, the committee included representatives from the Association of Counties, Association of County Engineers, Washington State Emergency Management Association, Association of Washington Cities, Northwest Indian Fisheries Commission, Governor's Office of Indian Affairs, State Representative Doug Sayan, and the State Departments of Wildlife, Fisheries, DNR, and Ecology.

The committee first agreed upon a definition of "emergency work." They planned a more organized, cooperative approach to emergency response, and established a resource agency emergency phone number, (206) 753-6618. The committee also recommended identifying hazards and solutions prior to flood events on a long term planning basis.

After the January 1990 floods, interagency cooperation again became an issue of concern. Review of both emergency *and* long term

recommendations appeared necessary, with a special emphasis upon long term planning. "Intermediate work," or work done between the emergency phase and the long term, also emerged as a significant issue for consideration in the agreement.

This review project is under consideration to be turned over to the Emergency Management Committee of the Association of County Engineers and will include all the same players. This project will be coordinated with the other pertinent projects in the State Flood Mitigation Document.

7. Stormwater

Through the Puget Sound Water Quality Plan, an on going effort addresses water quality and quantity issues. This effort should be reviewed and reflected in the State Flood Mitigation Plan.

8. Sediment

The issues surrounding river sediment removal are many-faceted and evoke strong pro and con feelings. Leaving sediment intact meets many resource needs, but often inhibits flood mitigation and flood fighting.

The advantages and disadvantages of sediment removal have not been sufficiently researched to make realistic blanket solutions. Mitigation representatives suggest that each river system should be studied as a whole, taking all interests into consideration. This process could be included in the long-term Emergency Management Committee work on Watercourses, facilitating agreement upon emergency, intermediate, and longterm work.

LEAD AGENCIES:

WSDCD/DEM and the State Mitigation Group (if and when established). Otherwise: WSDOE

SUPPORT AGENCIES:

Other State and Federal Agencies as needed.

POTENTIAL FUNDING SOURCES:

None needed

SCHEDULE:

During the review of the Section 409 State Flood Mitigation Document.

WORK PROGRAM ELEMENT NO. SWE-11

TITLE: Seaview/Long Beach Area, Pacific County

DESCRIPTION OF THE PROBLEM:

The ground surface in the lower reaches of the South Main drainage basin is only slightly above the sand bar at the ocean outfall. During significant storms (usually once a year) the hydraulic gradient of the storm water in the south main ditches results in flooding of the lower lying areas. This area includes approximately 878 acres, 300 houses, and 6 small business that are damaged by shallow, slow moving water.

BACKGROUND:

The South Main drainage basin suffers some flood damage every year. To prevent flooding during storm events, it will be necessary to increase the hydraulic gradient at the ocean discharge. To increase the gradient, Pool Engineering Inc.(a consultant) recommended in 1985 to construct a retention basin and a discharge structure near the outfall. The retention basin will store storm water between high tide events and allow rapid emptying during low tide periods. The discharge from the basin would be piped under the fore-dune to prevent excessive cuts through unstable sand. The existing open dune cut requires almost continual maintenance and during major storms is often ineffective at transmitting flow to the ocean.

ALTERNATIVE SOLUTIONS:

1. Elevate all structures, roads and bridges. This solution would be very expensive and is not cost effective.

2. Construct multiple outfalls for the South Main Sub-basin.

3. Upgrade existing system with construction of retention basin, or dam, and discharge structure with a tide gate. If necessary, install a pump to enable the discharge during high tides. Reestablish the outer dune to prevent the inflow of sea water.

4. Elevate the most flood prone residences approximately 1.5 feet, in addition upgrade discharge system (item 3 above).

RECOMMENDATIONS:

Upgrade the existing South Main System. Construct a retention basin of dam, and a gravity outfall structure similar to the design recommended by Pool Engineers, or install a pump if necessary. Reestablish the outer dune.

LEAD AGENCIES:

Pacific County, WSDCD/DEM

SUPPORT AGENCIES:

USDA, SBA, FEMA

POTENTIAL FUNDING SOURCES:

WSDCD/DEM-FEMA Section 404, Local Taxing District.

SCHEDULE:

Start construction after funding approval

WORK PROGRAM ELEMENT NO. SWE-12

TITLE: Snoqualmie River at the City of Snoqualmie

DESCRIPTION OF THE PROBLEM:

The November, 1990 flood caused widespread damage throughout the city and on surrounding land. Approximately, 60 per cent of the 550 homes within the City of Snoqualmie were damaged. During the peak of the flood the police building had to evacuated. There are no flood control structures at Snoqualmie. The United States Geological Service figures indicate that the November 1990 flood peak was the "flood of record" for Snoqualmie.

BACKGROUND:

The City of Snoqualmie was also hit by a flood in November, 1986, which caused approximately $4 million in total damages within the city and on adjacent county lands. As a result of the 1986 flood, about 20 homes were floodproofed and did not receive damage in the 1990 flood. The 1990 flood was, however, even more damaging to the city than the 1986 flood.

ALTERNATIVE SOLUTIONS:

1. Floodproofing all buildings which are subject to flooding in Snoqualmie, with the exception of those which have been identified for purchase (see Alternative Solution No. 4 below).

2. Investigate the possibility of modifying the existing Snoqualmie Falls Dam to reduce flooding in the city.

3. Investigate the feasibility of modifying the river channel upstream of the Falls to reduce flooding in the city.

4. Identify high risk and unsafe structures and research the possibility of purchase of property.

RECOMMENDATIONS:

1. FEMA, with county and city participation, should conduct workshops within the city to encourage floodproofing.

2. As part of Puget Power's re-licensing study for its Snoqualmie Falls project, the county, city and Puget Power should continue to explore the possibility of modifying the existing Falls dam to reduce upstream flooding.

3. The county and city should further consider sponsoring a USACE Section 205 Study to analyze the feasibility of modifying the channel to reduce flooding.

4. About five structures that abut the river are exposed to greater velocities and flood depths than other neighborhoods. Each are covered by flood insurance and appear eligible under Section 1362.

LEAD AGENCIES (BY RECOMMENDATION NUMBER):

1. FEMA

2. County, City and Puget Power

3. USACE

4. City of Snoqualmie, FEMA

SUPPORT AGENCIES (BY RECOMMENDATION NUMBER):

1. FEMA

2. USACE

3. County and City

4. FEMA 1362

POTENTIAL FUNDING SOURCES (BY RECOMMENDATION NUMBER):

1. FEMA, SBA funds, Commercial

2. Puget Power Funds

3. USACE Section 205 funds

4. FEMA 1362

SCHEDULE (BY RECOMMENDATION NUMBER):

1. As soon as possible, as part of the recovery process.

2. Ongoing action through mid-1990's

3. To begin as early in 1991 as possible. About five years to complete the project.

4. As soon as possible, as part of the recovery process.

WORK PROGRAM ELEMENT N0. SWE-13

TITLE: Cedar River

DESCRIPTION OF THE PROBLEM:

Problem I. Lower Reaches (Submitted by the City of Renton)

Record high water levels were recorded along the entire length of the Cedar River as a result of the November, 1990 storm, an approximately 70 year event. Extreme localized flooding was experienced in the vicinity of the river mouth and as far as two miles upstream. Three quarters of the Renton Municipal Airport was under water. Adjacent industrial and manufacturing facilities were inundated. Damage to city and privately owned property was reported in excess of $3.5 million.

Flooding in this area is increasingly severe and occurs with evermore frequent storm events. Protection from rising waters of the Cedar River needs to be extended up to the 100 year storm event.

When a system of canals and locks were constructed in the early 1900's to connect Lake Washington to Puget Sound, the Cedar River was diverted to its present course. Up to the mid 1980's the Cedar River through Renton was routinely dredged as part of a program to maintain the canal's capacity for conveyance and flood control.

Annual maintenance of the channel has stopped because of the combined effects of a lack of funding, a lack of appropriate mechanisms to accomplish program objectives, and increasing environmental scrutiny and criticism. The result is more frequent and severe flooding problems in the vicinity of the mouth of the river. The backwater effect the gravel deposits has grown tremendously as the delta at the river mouth has increased and the channel cross section upstream of the delta is continuing to decrease due to sedimentation/aggregation.

Other communities situated at the mouths of Lake Washington and Puget Sound tributaries have experienced similar dilemmas. A common problem seems to be that no procedures have been set up to evaluate and find mutually acceptable mitigative solutions to these flooding problems.

Problem II - Basin Flooding (Submitted by the U.S.Army Corps of Engineers - USACE)

The November, 1990 floods caused widespread damage throughout the Cedar River basin, and was the worst flood in recent history. Severe damage to homes, stores, bridges, roads, and the Renton Airfield occurred.

Chester Morse Lake, within the upper basin of the Cedar River, is the City of

Seattle's main source of drinking water. The operation of this reservoir often causes a reduction in downstream flooding; however, the reservoir could be operated in a manner that would further reduce Cedar River basin flood damages.

Problem III - Operate Masonry Dam Spillway Gates for Flood Control (Submitted by King County Surface Water Management Department)

The City of Seattle operates a series of dams on the Cedar River. Substantial water storage is achieved in the upper watershed at Chester Morse Lake, the impoundment above the Masonry Dam. Although operations at Masonry Dam are primarily designed for water supply and power generation, Seattle has provided "incidental" flood control by leaving Chester Morse Lake partially vacant during the flood season. This "incidental" flood volume filled before the Thanksgiving flood peak occurred, providing little relief downstream. The Cedar River registered flows of 10,200 cfs, a record high, at Renton on November 24, 1990.

Substantially improved flood control can be provided by deliberate manipulation of Chester Morse Lake levels through the operation of Masonry Dam. However, such manipulation requires substantial staff expertise which does not now exist within the local governments affected. Because the USACE has such expertise, in 1988 the City of Seattle (in cooperation with King County, the City of Renton, and the Washington State Department of Natural Resources) contracted the USACE to study flood control opportunities at Chester Morse Lake. Upon study conclusion, the recommended operating plan would be implemented by the USACE directing the operation of Masonry Dam spillway gates during a flood.

The most recent USACE plan would control flows to 5,000 cfs at the Renton Gage, with a two staged flood control rule curve for storage operation.

A preliminary King County study confirms that both the Veteran's Day flood and the record-setting Thanksgiving flood could have been substantially reduced by either of the two proposed operating schemes. Most, if not all, of the flood damage along the Cedar River could have been prevented by flood control operation of Masonry Dam.

Unfortunately, this opportunity was missed. The USACE study has not yet been completed. Moreover, the City has recently indicated reluctance to operate the dam for flood control if and when their study is completed due to liability issues.

The USACE, the City of Seattle, and other sponsors are in continuing discussions to determine the next steps in the study process and the costs for several study alternatives.

KEY RECOMMENDATION:

Important technical and philosophical differences apparently exist between the parties in this matter. It is essential that a consensus be reached and a mutual agreement for a common program be obtained. It is recommended that the

USACE (Mark Ekman) organize and chair a meetingto arrive at a solution or solutions to the problem.

RECOMMENDATIONS - PROBLEM I:

1. Respond immediately to the Cedar River conveyance deficiencies by removing the delta and dredging the river channel in order to avoid additional near term losses.

2. Commence a Comprehensive Flood Management Study of the Cedar River to identify the sources of the flooding problem and develop with a long term maintenance program.

3. Accomplish a comprehensive sedimentation analysis of the Cedar River system to evaluate the aggregation problem and assist in the design of technical and environmentally feasible permanent measures to ensure future channel capacity.

ALTERNATIVE SOLUTIONS - PROBLEM II:

1. Change the operation of the reservoir to reduce Cedar River flooding.

2. Relocate floodprone homes along the Cedar out of the floodplain and develop the vacated land into riverfront parks.

3. Where feasible and practical, improve existing levees to withstand 100-year floods.

RECOMMENDATIONS - PROBLEM II:

1. Consider resuming the USACE Section 205 Study to test feasibility of modifying reservoir operation to reduce downstream flood damages.

2. King County should conduct a study to investigate the possibility of relocating flood prone homes out of the floodplain and developing riverfront parks on the vacated land.

3. King County should conduct a study to investigate the possibility of improving existing levees to withstand 100-year floods.

ALTERNATIVE SOLUTIONS - PROBLEM III:

1. The USACE would complete the dam operation study and implement its recommendations.

2. The local governments can continue the USACE study, agree upon dam operation procedures, and either hire new staff or train existing staff to

implement the agreement.

3. Incidental flood control can continue without deliberate operation or dependable benefit.

RECOMMENDATIONS - PROBLEM III:

The above alternatives are ranked in order of recommended priority.

LEAD AGENCIES - PROBLEM I (BY RECOMMENDATION NUMBER):

1. USACE
2. King County
3. FEMA / USACE

LEAD AGENCIES - PROBLEM II (BY RECOMMENDATION NUMBER):

1. USACE / City of Seattle
2. King County
3. King County

LEAD AGENCIES - PROBLEM III (BY RECOMMENDATION NUMBER):

1. USACE / City of Seattle
2. King County

SUPPORT AGENCIES - PROBLEM I (BY RECOMMENDATION NUMBER):

1. USACE, WSDOE, WSDOF, WSDOW, Local Government agencies.
2. FEMA, WSDOE, WSDOF, WSDOW, Local government agencies.
3. USACE, WSDOE, WSDOF, WSDOW, Local government agencies.

SUPPORT AGENCIES - PROBLEM II (BY RECOMMENDATION NUMBER):

1. King County, Seattle Water Department, and Renton
2. King County and/or FEMA
3. USACE

SUPPORT AGENCIES - PROBLEM III (BY RECOMMENDATION NUMBER):

USACE, WSDOE, King County, City of Renton.

FUNDING SOURCES - PROBLEM I (BY RECOMMENDATION NUMBER):

1. FEMA, USACE
2. WSDOE (FCAAP)
3. FEMA

POTENTIAL FUNDING SOURCES - PROBLEM II (BY RECOMMENDATION NUMBER):

1. USACE Section 205, and Renton, King County, and Seattle Water Dept.
2. King County and FEMA
3. King County

POTENTIAL FUNDING SOURCES - PROBLEM III:

USACE if their participation can continue. If not, FEMA mitigation funds (Section 404) should be used to assist local assumption of the Corps role.

SCHEDULE - PROBLEM I (BY RECOMMENDATION NUMBER):

1. Begin immediately
2. Begin immediately
3. Begin May, 1991 (As a part of the FEMA HAzard Mitigation Grant Program Plan.)

SCHEDULE - PROBLEM II (BY RECOMMENDATION NUMBER):

1. Within months
2. As soon as possible
3. As soon as possible

SCHEDULE - PROBLEM III (BY RECOMMENDATION NUMBER):

1. The USACE probably can continue with the study and probably implement the new dam operations if the Seattle Water Department and King County agree to "hold and save" conditions of Federal involvement.

2. (If necessary) As soon as possible.

3. N/A

WORK PROGRAM ELEMENT NO. SWE-14

TITLE: Interdependency between urban development and watershed forest practices

DESCRIPTION OF THE PROBLEM:

Riverine flood damage to urban and suburban development in the mid and lower reaches of the State's drainage basins has occurred with increasing frequency and intensity.

BACKGROUND:

The flooding of urban and suburban development on and near the flood plains of rivers with headwaters in forested watersheds is increasing. This flooding appears to be both a function of both increased urbanization and harvesting practices within the watershed.

At the IHMT meetings for the January, 1990 floods (FEMA 852-DR-WA) and again in two separate team meetings convened following the floods of November, 1990, there were discussions concerning floodflows and the effects of increasing urbanization on surface water run-off. It was suspicioned that the increase in rapid run-off was due, at least in part, to clear cuts in the upper watershed, but there is insufficent research. It was the general consensus, however, that the dynamics of flooding within western Washington were changing.

Current forest practices in watersheds and their effects on flood levels during periods of heavy rainfall and snow melt have been regarded with increasing suspicion by floodplain managers. Similarly, the urbanization of floodplain lands may be placing existing forest harvest practices in jeopardy.

There is a dearth of reliable information on how clear-cutting effects flood levels, Much of this information is contradictory.

ALTERNATIVE SOLUTIONS:

1. Continue to speculate on the question of forest practices' impacts on to flood levels.

2. Conduct and support a comprehensive study of the run-off patterns of selected watersheds, focussing upon the direct and secondary effects of timber harvesting.

3. Intiate an expanded study to investigate and determine the interrelationships, and interdependence between forest practices, floodplain management, growth management measures, and urbanizing development.

RECOMMENDATIONS:

A Steering Committee staffed by WSDOE and including representatives of WSDNR, King County Surface Water Management (including other local governments), U.S. Geological Survey, U.S. Forest Service, the National Park Service, the Center for Streamside Studies, WSDCD, and U.S. Soil Conservation Service should be formed to scope and oversee a comparative study of run-off patterns in selected watersheds. This study should also include a study of the effectiveness of floodplain management measures, and measures that could be implemented under the Washington Growth Management Act, and the interrelationship between these factors.

LEAD AGENCIES:

WSDOE

SUPPORT AGENCIES:

WSDNR, USFS, NPS, USGS, Univ. of Wash. CSS, WSDCD

POTENTIAL FUNDING SOURCES:

To be identified.

SCHEDULE:

Immediately, after the funding determination

APPENDIX A -- LIST OF ATTENDEES
INTERAGENCY FLOOD HAZARD MITIGATION MEETING

January 9 - 10 1991
FEMA 883-DR-WA

NAME	ORGANIZATION AND ADDRESS	PHONE
Barbara Betsch	Fish Analyst State of Washington 2420 Bristol Court FSIS 24 Olympia, WA	(206)586-5835
Wil Brannon	Supervisor Pierce County Public Works 1424 112th St. East Tacoma, WA 98445	(206)531-6990
Carl Cook	Chief, Natural Hazards FEMA Region X Bothell, WA 98021-9796	(206)487-4687
Paul Cooke	Study Manager Corps of Engineers Seattle District P.O. Box C-3755 Seattle, WA 98124	(206)764-3622
Harold Crowe	Construction Analyst Small Business Admin. P.O. Box 13795 Sacramento, CA 95853	(916)978-4568
Tim D'Acci	Community Assistance Washington Dept of Ecology MS:PV-11 Olympia, WA 98502	(206)459-6796
Stan Eccles	Disaster Response Planner FEMA Region X Bothell, WA 98021-9796	(206)487-4750
Dick Fleming	Lewis County Engineer Lewis County Public Works P. O. Box 899 Chehalis, WA 98532	(206)748-9121 Ext 123

NAME	ORGANIZATION AND ADDRESS	PHONE
Bob Freitag	Mitigation Officer FEMA Region X Bothell, WA 98021-9796	(206)487-4701
Charles Fulmer	Hazard Mitigation FEMA Region X Bothell, WA 98021-9796	(206)486-3437
Nancy Gloman	Assistant Field Supervisor U.S. Fish & Wildlife Service 2625 Parkmont Lane S.W. Olympia, WA 98502	(206)753-9440
Ed Hannus	E R Program Dept. of Transportation Olympia, WA 98504	(206)753-3311
Thomas Higgins	U.S. Geological Survey U.S.Geological Survey WRD 1201 Pacific Ave., Suite 600 Tacoma, WA 98402	(206)593-6510
Robert Hintz	Hazard Mitigation FEMA Region X 11010 - 40th Ave. NE Seattle, WA	(206)363-7544
Brenda Hostetter	Director Kitsap County 911/DEM 1720 Warren Ave. Bremerton, WA 98310	(206)478-5330
Reed W. Jarvis	Chief, Resources Mgr.& Visitor Protection National Park Service 83 South King St., Suite 212 Seattle, WA 98104	(206)553-5670
Raj Joshi	Hazard Mitigation FEMA Region X 1714 NE 58th St. Seattle, WA 98105	(206)524-6304

NAME	ORGANIZATION AND ADDRESS	PHONE
Jerry Louthain	Flood Plain Mgmt. Supervisor Dept. of Ecology MS PV-11 Olympia, WA 98504	(206)459-6791
Bob McBride	DEM Kittitas County Kittitas County Sheriff's Office 205 W. 5th Ellensburg, WA 98926	(509)962-7525
Mel Mefford	Sheriff Jefferson County 81 Elkins Rd. Port Hadlock, WA 98339	(206)385-3831
Andy Merz	Risk Analyst Div. of Risk Mgmt, G.A. 2420 Bristol Court, FS-24 Olympia, WA	(206)586-5835
Ron Merila	City Engineer City of Aberdeen 200 E. Market St. Aberdeen, WA 98520	(206)533-4100
Patrick Morrissey	Pacific County Engineer Pacific County Public Works P.O. Box 66 South Bend, WA 98586	(206)875-9368
Lora Murphy	State Mitigation Officer WSDEM/DCD 4220 E. Martin Way MS PT-11 Olympia, WA 98504	(206)459-9191
Robert Nesbitt	County Engineer Jefferson County P. O. Box 1220 Port Townsend, WA 98368	(206)385-9166

NAME	ORGANIZATION AND ADDRESS	PHONE
Ken Pick	Corps of Engineers Flood Plan Management U.S. Army Corps of Engineers P. O. Box C-3255 Seattle, WA 98124	(206)764-3661
Mike Redmond	Deputy Insurance Commissioner Office of Insurance Commissioner 3309 Capitol Way S.E. Olympia, WA 98504	(206)586-2488
Bill Satoris	Dept. of Community Dev. Division of Emergency Management 4220 E. Martin Way Olympia, Wa 98504-8611	(206)753-5255
Bob Schofield	Hazard Mitigation Region X 430 W. Shore Rd. Guemes Island Anacortes, WA 98221	(206)336-9334
Jerry Smith	Habitat Biologist Dept. of Wildlife 600 N. Capitol Way Olympia, WA 98504	(206)753-5897
Dick Weston	Road Operations Manager Thurston County 9700 Tilley Rd. Olympia, WA 98502	(206)786-5495
Dawn Whitehead	Field Supervisor U.S. Fish & Wldlife Service 2625 Parkmont Lane S.W. Olympia, WA 98502	(206)753-9440
Kim H. Whitman	Regional Director FEMA Region X Bothell, WA 98021-9796	(206)487-4604
Bill Wiggins	U. S. Geological Survey Information Office 1201 Pacific Ave., Suite 600 Tacoma, WA 98402	(206)593-6520

NAME	ORGANIZATION AND ADDRESS	PHONE
Gordon Taxer	Civil Engineer Readiness USACE North Pacific Division P.O. Box 2870 Portland, OR 97208	(503)326-6858

APPENDIX B
FEMA-883-DR-WA
FEMA-883-WA-DR INTERAGENCY HAZARD MITIGATION TEAM AGENDA

WEDNESDAY, JANUARY 9, 1991

10:00 am	Welcome	Richard Buck, DFCO/ Cathy Turk, DSCO
10:15 am	Purpose and Objectives	Lora Murphy/ Bob Freitag
10:30 am	Introductions	Attendees
10:45 am	Description of the Storms	
11:00 am	Break	
11:15 am	Presentation of Results- Initial Haz Mit Meeting	Raj Joshi
12:00 n	Lunch	
00 pm	Description of Damage for the Add-on Counties	
1:45 pm	Identification of Issues	Hazard Mitigation Team Members
3:00-3:15 pm	Break	
3:15 pm	Continue Identification of Issues	
4:00 pm	Adjourn	

AFTER HOURS Special Issues - Selected Team Members

THURSDAY, JANUARY 10, 1991

9:00 am	Definition of Problems - Formation of Problem Area Teams	
10:00 am	Break	
10:15 am	Work on Work Elements	Teams
12:00 am	Lunch	
1:00 pm	Presentation of Work Elements	Problem Area Team Leaders
5:00 pm	Adjourn	

APPENDIX C

GLOSSARY

CDBG	HUD Community Development Block Grant Program
FCAAP	Flood Control Assistance Account Program
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIS	Flood Insurance Study
FmHA	U.S. Farmers Home Administration
HMGP	Hazard Mitigation Grant Program
HUD	U.S. Department of Housing and Urban Development
IHMT	Interagency Hazard Mitigation Team
NFIA	National Flood Insurance Administration
NPS	National Park Service
NWS	National Weather Service
SBA	Small Business Administration
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Department of Environmental Protection
USF&W	U.S. Fish and Wildlife Service
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USSCS	U.S. Soil Conservation Service
WSDCD/ DEM	Washington State Department of Community Development, Division of Emergency Management

APPENDIX C - GLOSSARY - CONTINUED

WSDCD	Washington State Department of Community Development
WSDNR	Washington State Department of Natural Resources
WSDOA	Washington State Department of Agriculture
WSDOE	Washington State Department of Ecology
WSDOF	Washington State Department of Fisheries
WSDOT	Washington State Department of Transportation
WSDOW	Washington State Department of Wildlife
WSDTED	Washington State Department of Trade and Economic Development

APPENDIX B

CENPS-OP-NP

MEMORANDUM THRU Chief, Operations Division

FOR Chief, Emergency Management Branch

SUBJECT: Flood Fight Report, Chehalis River Basin
9 - 12 January 1990

1. Date of Flood: 9 January 1990

2. Starting Time: 0900

3. Persons Involved:

Corps - Eric Winters, Cheryl Buckel, Thomas Landreth, James Skrinde, Steven Hansen, and Patricia Carroll.

Lewis County - Jeanne Massingham, Maureen Stubbins, Bill Fourth, Bob Burg, Homer Wiltrip.

Tuesday 9 January:

4. Eric Winters started at 0900 contacting our Corps H&H weather people about weather conditions on the Chehalis River. After receiving the predictions I called Lewis County Emergency Services and gave them the weather report and they said at this time there was not a problem but the county was receiving calls about sandbags. I informed Emergency Management of the county's situation.

5. Between 1000 and 1300 phone calls were made between the Seattle District office and Lewis County with weather reports and river predictions given.

6. At 1300 Eric Winters received a call from Jeanne Massingham, Lewis County Emergency Management Services. She said we need your assistance and bring at least 20,000 sandbags. Their supply was exhausted.

7. At that time the Chehalis flood team was mobilized and each vehicle that left the District had at least 5,000 sandbags on board. I called Thomas Landreth and he went from Aberdeen to Fort Lewis and picked up 5,000 sandbags that Emergency Management had on hand for this type of emergency. A total of 38,000 bags were delivered to Lewis County.

8. At 1620 our first two vehicles arrived at the Lewis County Courthouse and unloaded 12,000 sandbags. In the next 45 minutes another 20,000 bags arrived.

9. At 1700 Eric Winters went to the Lake Shore Motel and looked at the Skookumchuck River and China Creek. They were going to flood the motel no matter how many bags were put down.

10. Cheryl Buckel was at the Lewis County Emergency Services office setting up the Corps E.O.C. for radio communications and information gathering.

11. At 1800 I went to the airport with the Civil Air Patrol Major. The south end was already flooded but the levee was holding. The C.A.P. Major said the weather was too bad at this time to fly out of the airport.

12. By 2000 the Chehalis River was starting to rise 1 foot per hour. Looking at the maps and elevations, the only thing we could do at that time was to sandbag in areas that would help save levees and keep water from cutting through into Centralia from the Skookumchuck River. China Creek and Salzer Creek were flooding to the point that the freeway outflow would not handle the water.

13. At 2100 Interstate 5 was closed northbound until further notice. The Chehalis River was still coming up 1 foot per hour.

14. 2200 to 2400 - The Skookumchuck River has broken through by the Huntly Inn and has flooded Centralia's north end. Upstream from the Pearl Street Bridge we monitored our project but found overtopping upstream of our project. Eric Winters mobilized sandbaggers to fight the overtopping and they were being successful until a small bridge further upstream plugged with debris and caused the Skookumchuck to go out of its banks and flood a portion of the old railroad grade which had the track and ballast removed. At this time we were working with Lewis County, City of Centralia, and Civil Air Patrol volunteer sandbaggers. When the water started rising too rapidly, I gave the order to stop sandbag operation and the county, city, and National Guard started to evacuate the area. I feel that the sandbagging we did in this area was of help and stopped a concentrated flow of water that would have developed if these sandbags were not put in the key places.

Wednesday 10 January:

15. 0100 - Sandbags were used throughout this time for small businesses to divert water and levee problems. The county and cities were using all their resources with the National Guard.

16. At 0300 evacuation assistance requested for Riverside Convalescent Home. National Guard responded with the county. Search and Rescue chapters were asked for by Lewis County.

17. 0700 - We now realize that Lewis County has had record flooding and that we must move our operation to the west. Tom Landreth went to Porter.

18. At 0800 Interstate 5 was completely closed both north and southbound to through traffic.

19. By 1000 James Smith, Duane Johnson, Tom Landreth, and Mitch McGregor were following the Chehalis River flood to Aberdeen.

20. At 1045 I picked up Congresswoman Unsoeld and gave her a tour of the Lewis County flood area. She was overwhelmed by the size and scope of the flooding. She was concerned with the flooding of the airport, sewage treatment plants, Chehalis dump site, and individual houses. Estimated about 1,500 families affected by flooding. Lewis County Commissioners taken up on helicopter rides to assess damage.

21. 1100 - Information coming in from Grays Harbor County. Sent 30,000 sandbags just in case county requested bags. Corps flood team monitored gauges during high tides. Personnel on hand: James Smith, Duane Johnson, Tom Landreth, Richard Burnham, and Mitch McGregor.

22. At 1745 Duane Johnson and James Smith went to sandbag at Oakville.

23. At 2000 Cheryl Buckel departed for the Seattle District Office. Eric Winters and James Skrinde manned the radio. Patricia Carroll reserved rooms at Castle Rock because the motel was flooded.

24. 2030 - James Smith manned the radio until 0630 in the morning.

25. 2200 - The Chehalis flood team worked in Grays Harbor County checking tide gauges and for levee failures.

Thursday 11 January:

26. 0100 to 0830 - Flood team in Grays Harbor County working with county.

27. At 0900 Eric Winters went out with Lewis County's Bill Fourth on road and flood inspection. The State is trying to ready Interstate 5 to open. Chehalis River still above flood stage of 65 feet. Will maintain office.

28. By 1700 the county is using a rented Crisafulli pump to dewater the fairgrounds. There is a 29,000 gpm pump station in the fairgrounds.

Friday 12 January:

29. 0750 - LTC Jacobs will fly via helicopter through Grays Harbor and Lewis County. The helicopter had a breakdown and did not complete the mission.

30. By 0900 Interstate 5 is open north and southbound to traffic.

31. At 1100 Richard Burnham stopped at the Lewis County E.O.C.

32. By 1300 Chehalis River went below flood stage and E.O.C. was closed and the team was recalled to Seattle by the Corps District office.

ERIC WINTERS
Flood Engineer